Issued July 12, 1913.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN 127.
HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

THE GRINDING OF SPRUCE FOR MECHANICAL PULP.

BY

J. H. THICKENS,
Chemical Engineer in Forest Products.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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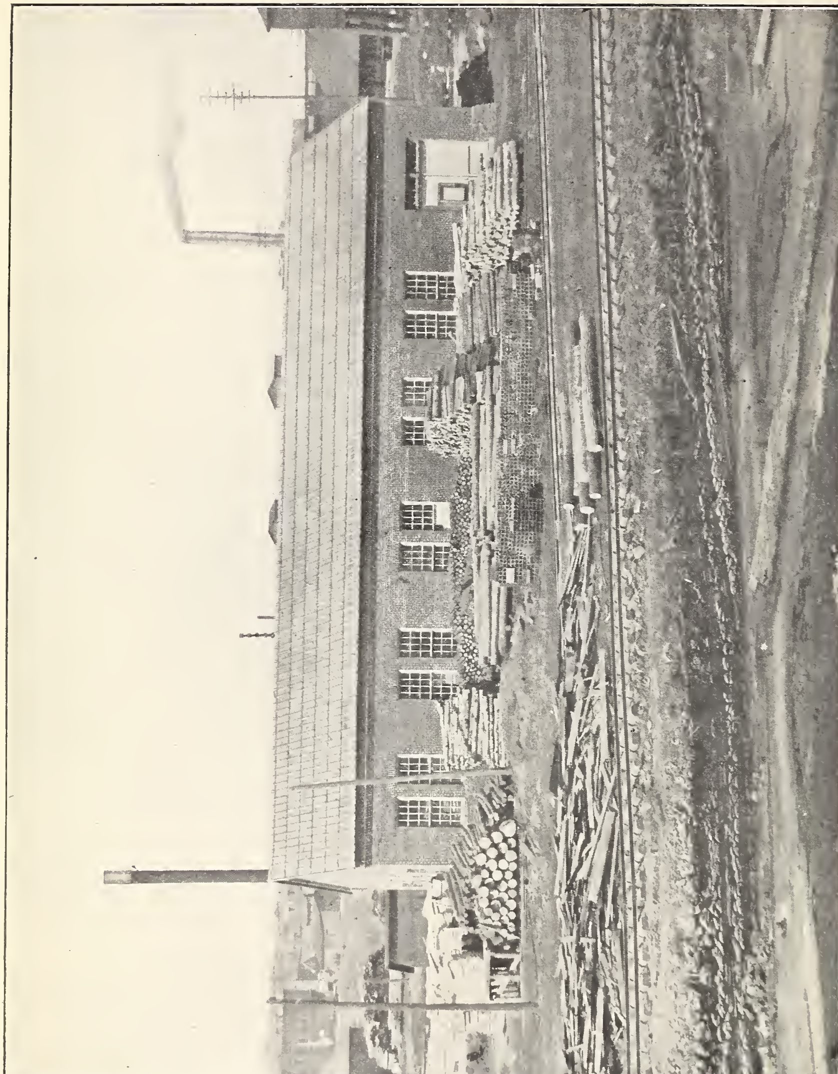

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., December 11, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "The Grinding of Spruce for Mechanical Pulp," by J. H. Thickens, chemical engineer in forest products, and to recommend its publication as Bulletin 127 of the Forest Service.

The investigation was carried on at the Forest Service Groundwood Laboratory at Wausau, Wis., a branch of the Forest Products Laboratory at Madison, Wis., in cooperation with the American Pulp and Paper Association and the University of Wisconsin.

Respectfully,

Henry S. Graves,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

Additional copies of this publication may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 15 cents per copy

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THE GRINDING OF SPRUCE FOR MECHANICAL PULP.

COMMERCIAL GRINDING PRACTICE.

The commercial manufacture of ground-wood pulp is generally not conducted according to any fixed standards of practice. Each superintendent or manager has his own theories about the method of grinding. As a result, scarcely any two mills operate under the same conditions, even when grinding the same species and turning out similar products. This is strikingly shown in Table 2, which gives the operating conditions of a large number of mills throughout the United States. For example, one mill producing news paper has 15 grinders, to each of which is applied 135 horsepower; the pressure computed to the basis of a 14-inch cylinder is 17.5 pounds per square inch, and the peripheral speed of the stone is 2,660 feet per minute. In another mill, also producing news paper, each of the 16 grinders has 625 horsepower applied to it and uses a pressure of 72 pounds on a 14-inch cylinder and a peripheral speed of 3,540 feet. A variation of from 135 to 625 horsepower to the grinders is seen in the example cited. While these two mills also show much variation in other conditions of grinding, they do not show the extreme conditions, where the pressure applied to the wood in grinding varies, as shown in the table, from 17.5 to 115.8 pounds on a 14-inch cylinder, and the peripheral speed of the stone from 1,360 to 4,310 feet per minute. The variation in pressure per square inch of pocket area would be more significant, but the data on which to base this computation were not available in all cases.

The reports of power consumption show a range of from 31 to 125 horsepower per ton in 24 hours. Very few mills, however, are able to determine accurately the amount of power consumed in the production of a ton of pulp, for the grinders are nearly always either geared or direct-connected to water wheels or turbines. When turbines are new it is possible to calculate approximately the amount of power produced, but as they become old their efficiency decreases, and it is impossible to calculate the power with any degree of accuracy. It is very probable that many of the reported values are erroneous, especially some of the lower ones, since it has been demonstrated that pulp can not be produced under conditions of present commercial

practice with a power consumption as low as some of the values reported.

In view of the extreme variation in the conditions of manufacturing mechanical pulp it is probable that some of the mills are operating under conditions of low efficiency. While the tests discussed show that approximately the same degree of efficiency may be reached by different combinations of the several variable factors, consistent combinations of these factors do not prevail in the industry.

PURPOSE OF EXPERIMENTS.

The cost of producing mechanical pulp from spruce must necessarily increase with the cost of the wood. In order to cut down the price of mechanical pulp, therefore, it is necessary either to substitute a cheaper wood for spruce or to increase the efficiency of converting spruce into pulp. Experiments are being conducted in the use of woods other than spruce by the mechanical process, but before these can be carried to a definite conclusion it is necessary that the influence of many variable conditions of manufacture be determined. This can best be done by tests of a standard wood like spruce. Coniferous woods are enough alike to warrant grinding them under approximately similar conditions, and the results of the grinding tests on spruce should be applicable to the production of mechanical pulp from other conifers. The study of spruce, however, is of value not only in establishing relations and standards by which to compare the results of tests of proposed substitutes, but also in developing methods of increasing the efficiency of grinding spruce itself.

The general influence of the variable factors of grinding on the quality and production of pulp has been described in a previous publication [1] of the Forest Service, in which the need for a more thorough study of the conditions of grinding was indicated. The most important factors which enter into the production of mechanical pulp from any species of wood are:

(1) Surface of stone; whether rough or smooth, sharp or dull, or of coarse or fine grit.

(2) Pressure with which the wood is forced upon the revolving pulpstone.

(3) Peripheral speed of the stone.

(4) Temperature of grinding and thickness of stock in the grinder pit.

(5) Physical condition of the wood.

As a result of operating under different combinations of these factors, certain other factors are developed, and it was the purpose of

[1] "Experiments with Jack Pine and Hemlock for Mechanical Pulp," by J. H. Thickens.

the experiments to determine the influence of variation of these upon:

(1) Power applied to the grinder.
(2) Amount of pulp produced in 24 hours.
(3) Power consumption per ton of pulp in 24 hours.
(4) Yield of pulp and screenings per cord of wood ground.
(5) Quality of the pulp.

EXPERIMENTAL APPARATUS.[1]

EQUIPMENT FOR WOOD PREPARATION.

For treating woods prior to grinding a steaming or treating tank, holding between one-fourth and one-half cord of wood, is available. This tank is so designed that the wood can be loaded from the top and discharged from the bottom. To carry out tests under different conditions the tank is provided with steam, water, and vacuum connections. A 40-inch swing cut-off saw and a Roberts and Lieberts Green Bay barker are available. A view of the wood room is shown in Plate II, figure 1.

PULP-MAKING EQUIPMENT.

For grinding, a Friction Pulley & Machine Works 3-pocket grinder, with cylinders 14 inches in diameter, and taking a stone 54 inches diameter by 27 inches face, is used. The grinder cylinders are supplied with water by two Gould triplex pumps. Suitable relief valves are provided for the regulation of the water pressure, and pressure gauges are attached to each cylinder. A graphic recording thermometer connected with the grinder pit gives the temperature of grinding. A Lombard medium-grit stone was used.

The grinder is driven by a direct-connected, direct-current, variable-speed motor, regulated by adjusting the armature voltage. Electric current, alternating, is obtained at 2,300 volts. This is converted by a motor generator set to direct current, the voltage of which can be fixed at any value between 100 and 750 volts by means of a rheostat in the generator field. The measurement of power and the control and regulation of the motor are accomplished by means of carefully calibrated recording, indicating, and integrating instruments. A graphic record is taken of the power applied to the grinder motor, and an integrating watt-hour meter provided in the same circuit makes possible a check on power consumption.

The pulp-screening system consists of a Ruth's centrifugal screen with a plate perforated with holes 0.065-inch in diameter, and operated at 500 revolutions per minute, and a Harmon 12-plate flat

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[1] A more complete description of the equipment of the Forest Service laboratory at Wausau, Wis., is given in an unnumbered publication of the Forest Service, "Experiments with Jack Pine and Hemlock for Mechanical Pulp."

screen, the plates of which are slotted with 0.012-inch slots. The Harmon screen is used only in rescreening the tailings of the centrifugal. In forming the pulp laps, a wet machine of the hydraulic 3-roll type is used.

PAPER MAKING AND TESTING EQUIPMENT.

The experimental pulps were made into paper and tested at the Madison (Wis.) laboratory. A 15-pound Emerson beating engine, a 2-plate flat screen slotted with 0.012-inch slots, and a 15-inch Pusey-Jones Fourdrinier paper machine were used in the manufacture of the paper. A view of the paper machine is shown in Plate II, figure 2.

The strength tests of the paper were made by means of a Schopper breaking-length tester and a Mullen bursting-strength tester. The color tests were made with an Ives tint-photometer.

METHOD OF OPERATION.

PREPARATION AND TREATMENT OF THE WOOD.

The wood for the tests was sawed into 2-foot lengths, and the bark removed. Samples were then taken to determine the percentage of moisture and the bone-dry weight per cubic foot. In tests where preliminary steaming was applied the steam pressure was raised as rapidly as possible to the desired value and maintained for the specified time, after which the sections were removed from the steaming chamber and ground as soon as possible. The experiments in which a preliminary steaming or cooking treatment was used are not comprehensive. Additional results on the effect of such treatment will be given in a future publication.

A quantity of pulpwood equivalent to approximately 750 pounds of bone-dry wood was prepared for each test. This was ground as soon as possible to prevent change in its moisture condition from that recorded.

PULP MAKING.

The pulpstone was worked with a bush roll or burr until the desired surface was obtained. A record of the surface was taken with carbon and coated papers.

To make them comparable all of the tests were started on a cold stone. It was impossible in each case to grind a large quantity of wood for the purpose of heating the stone, since this would have dulled the latter and so have obscured the effects of varying other factors. Tests Nos. 143, 144, and 145 (Table 3) show that starting the tests with a cold stone has very little effect on the horsepower consumption per ton and the production per day. These three tests were conducted under similar conditions, except that No. 143 was run for a period of one hour, 144 for two hours, and 145 for three

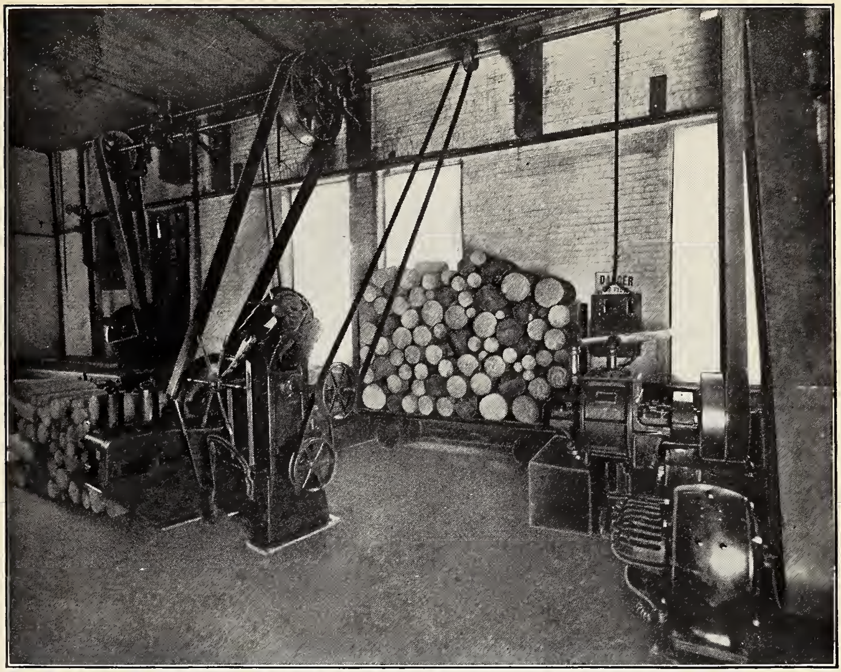

FIG. 1.—WOOD ROOM, GROUND-WOOD LABORATORY, WAUSAU, WIS.

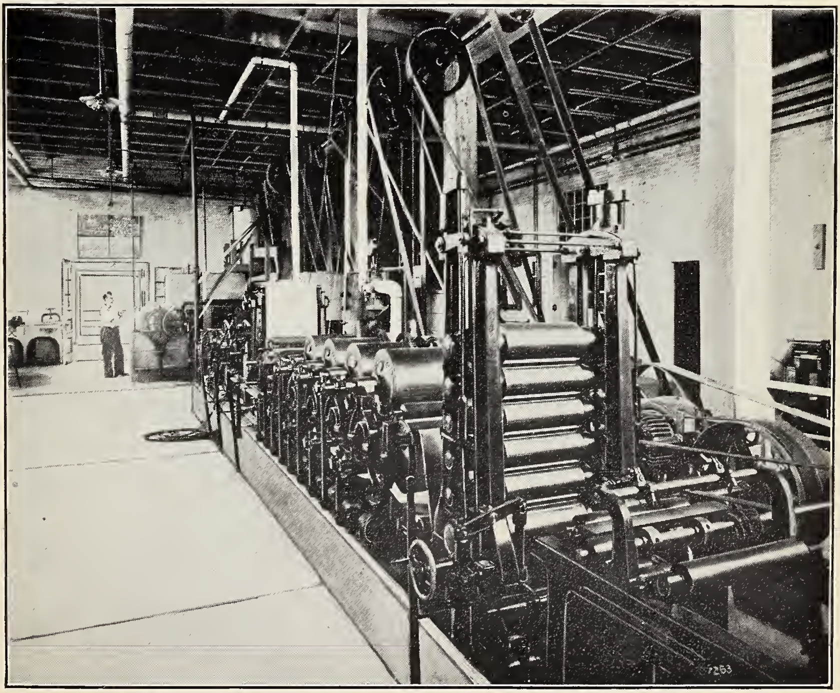

FIG. 2.—PAPER MACHINE, FOREST PRODUCTS LABORATORY, MADISON, WIS.

hours. Tests Nos. 144 and 145 were run on the same day, and the stone had become thoroughly heated before test No. 145 was begun.

In almost all cases the tests were conducted in series, throughout each of which the surface of stone was assumed to remain the same, since any change which might take place would not be great enough

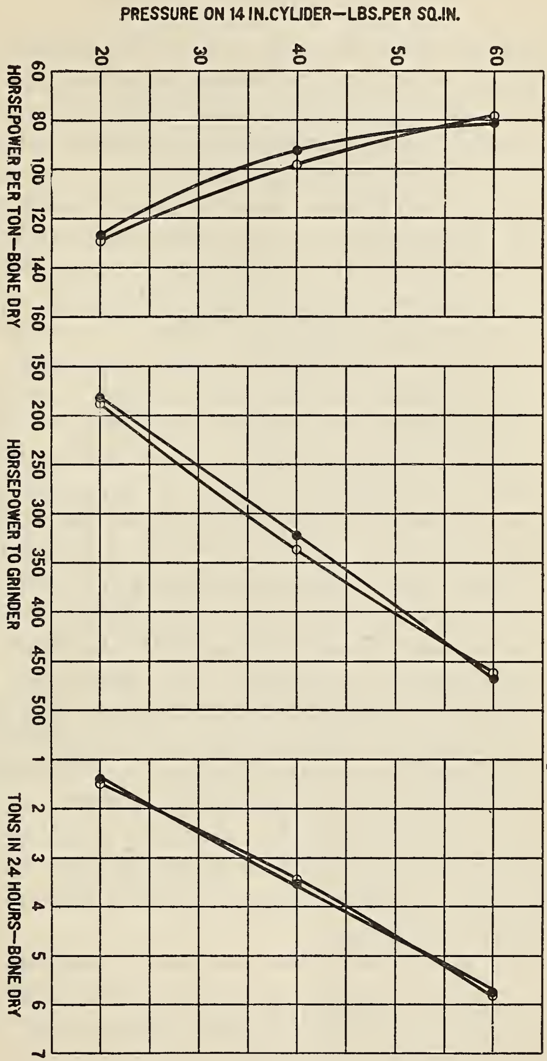

Fig. 1.—Similarity of test values on duplicate runs. (Runs Nos. 137 to 142, inclusive.)

to obscure the influence of the other factors under consideration. Figure 1 (runs 137 to 142) shows that actually the surface changed very slightly during the series of runs. In each case the two tests, which were conducted under the same conditions of speed and pressure, check one another very closely, although the stone had been

used considerably between the tests and the surface had had an opportunity to change. It was found almost impossible to duplicate a surface by successive burrings so that under conditions otherwise similar the power consumption and production would remain the same.

DETERMINATION OF QUALITY.

To study the quality of the pulp produced two methods were used—microscopical examination and manufacture into paper. The samples for microscopic study were taken from the wet-machine vat. Slides were made and photographed, as a means of comparing the relative amounts of long and short fiber.

In the manufacture of paper from the experimental pulps the laps were shredded and sampled for the determination of moisture, and on a basis of this determination 80 parts by weight (dry) of ground wood pulp were mixed with 20 parts of bleached spruce sulphite pulp. These materials were beaten lightly for approximately one hour, or until all of the fibers had been separated. The beaten pulp was then screened and run into waterleaf paper, the weight of which was maintained as nearly as possible at 32 pounds per ream of 500 sheets 24 by 36 inches. Uncalendered samples of the paper were tested for thickness, weight per ream, bursting strength by Mullen tester, tensile strength and stretch lengthwise and crosswise by Schopper tester. Relative amounts of green, blue, red, and black in the color were determined by means of a tint-photometer. The color determinations were made primarily for comparison with those on pulps produced from woods other than spruce.

In the determination of quality most stress was placed upon strength. However, a grading of the pulps by photomicrographs, according to standards selected from a large number of samples produced commercially, is given (Table 5). Photographs of these standards are shown in the publication, Experiments with Jack Pine and Hemlock for Mechanical Pulp. Since the grading by microscope is not consistent with the results of mechanical tests of strength, not much reliance can be placed upon the examination of the fiber for the determination of quality.

So far as the operation on the machine is concerned—and this is an important item of quality—the tests furnish little information. The paper machine on which the pulps were manufactured operates at extremely low speed, and comments on the freeness of the stock and its general action on the presses, or wire, would have little value.

The comparison of finishes obtained by calendering is also of little value and is omitted. The machine was not run continuously, and the paper was therefore finished at varying temperatures and speeds of the calender rolls.

RESULTS OF EXPERIMENTS.

SURFACE OF STONE.

The condition of the surface of the stone depends upon several factors. The size and sharpness of the individual particles of grit, the ease with which the binding material is worn away, and the manner of dressing the stone are important. In these tests but one stone was used, and variations in its surface were obtained by working it with steel rolls of different design.

The size and sharpness of grit should be given considerable attention, although this was not done in the work described. The indications are, however, that stones of fine grit are capable of producing more finely ground pulps, and that a stone of extremely coarse grit may produce very shivy pulp.

Commercially a great deal of attention has been given to the design of burrs or bush rolls. It appears, however, that practically the same quality of pulp can be obtained under like conditions of pressure, speed, and temperature if the surface of the stone is brought to the same condition of sharpness of grit, irrespective of whether the design of the markings is diamond point, straight cut, or spiral. The purpose of the depressions in the stone is primarily to provide a path by which the ground wood can leave it. It is possible that burrs of certain design will give a greater amount of grinding surface than others, and that the production will in this way be slightly increased.

Plates III and IV show some of the bush rolls used in surfacing the stone for runs, the data of which are given in Tables 3 and 4. The surface obtained by burring with the rolls shown on Plate III seemed to give more satisfactory results than any other thus far tried. The stone was first dressed with a 3-to-the-inch roll, and depressions were formed from one thirty-second to one-sixteenth of an inch deep. The stone was then rolled with a 12-to-the-inch spiral-cut burr until the spiral markings were plainly discernible. It is not at all essential that a spiral burr be used; any finely cut burr will give approximately the same results, the idea being, of course, to raise the grit of the stone. This is best done with a burr approaching the grit of the pulp stone in fineness.

The important thing, so far as quality is concerned, is to give the particles of grit the correct treatment, rather than to form a deeply-grooved surface on the stone. An artificial pulp stone so constructed that the binding material, although standing up under high temperature and high pressure, would wear away a little more rapidly than the grit, thus continually exposing new and sharp particles of grit for grinding, would be of immense value to the industry.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 2 shows, by curves obtained at pressures of 20, 40, and 60 pounds, the relation of three different surfaces of stone to the power consumption per ton, power to the grinder, and production in 24

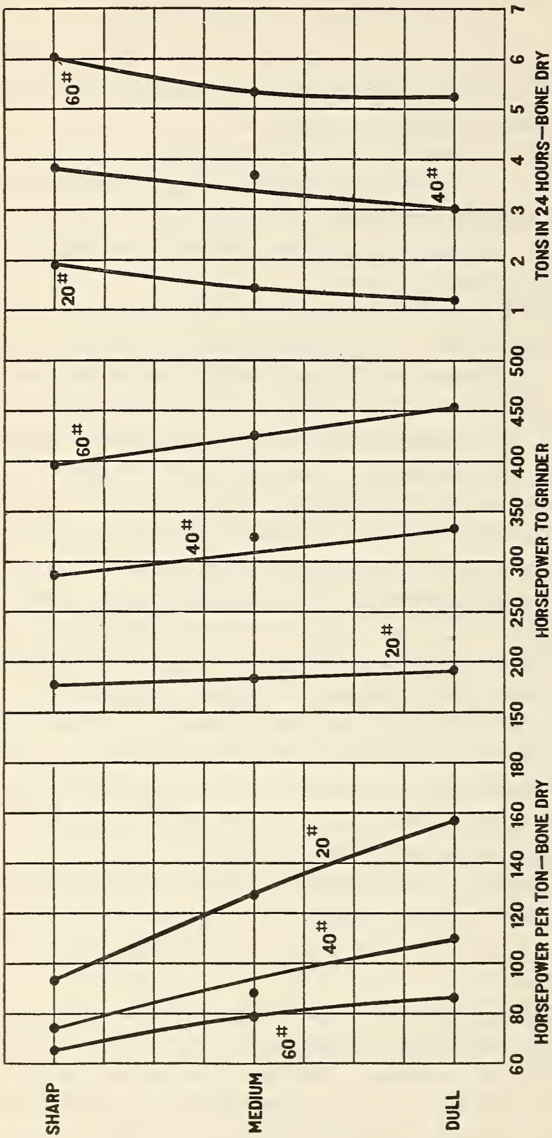

FIG. 2.—Relation of power consumption and rate of production to sharpness of stone, at 175 r. p. m. (Runs Nos. 3 to 5, 9-1 to 11, and 15 to 17, inclusive.)

hours. The horsepower per ton and the power to the grinder vary inversely with the degree of sharpness of the pulpstone, while the production varies directly with the sharpness. It is of particular interest to note that the curves apparently come together at a point

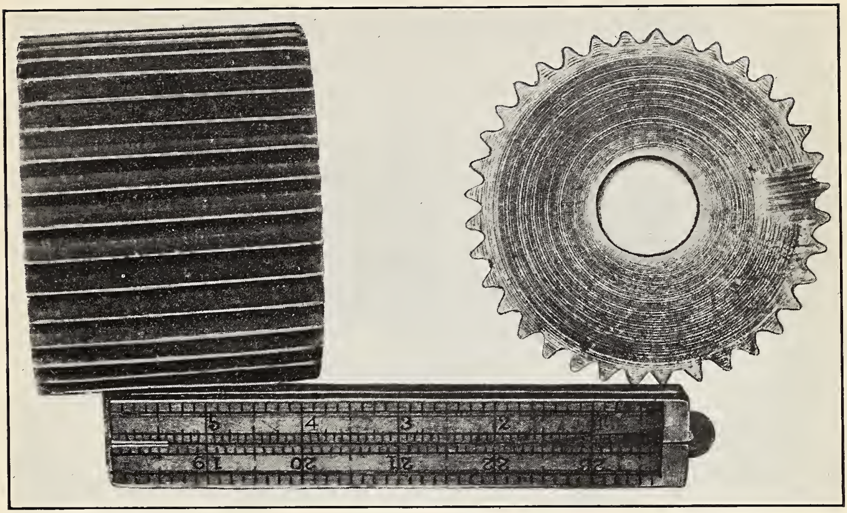

FIG. 1.—STRAIGHT-CUT BURR, THREE TO THE INCH.

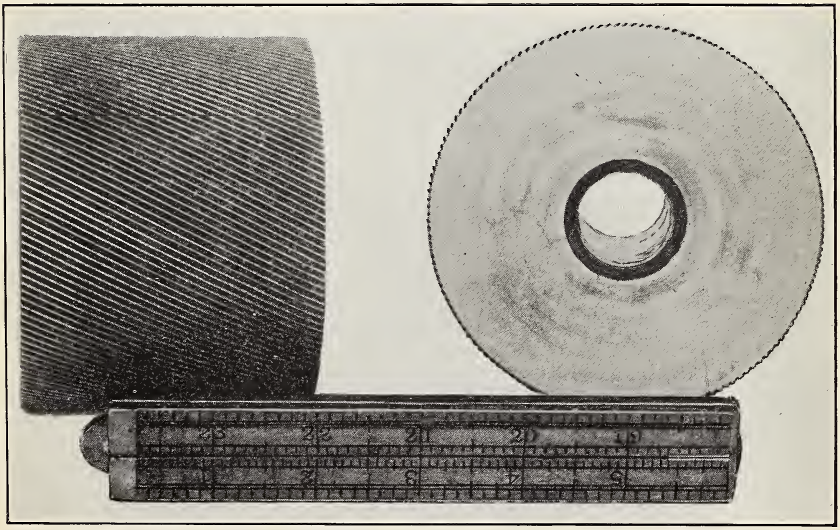

FIG. 2.—SPIRAL-CUT BURR, TWELVE TO THE INCH.

(Advance $1\frac{1}{2}$ inches in crossing 3-inch face.)

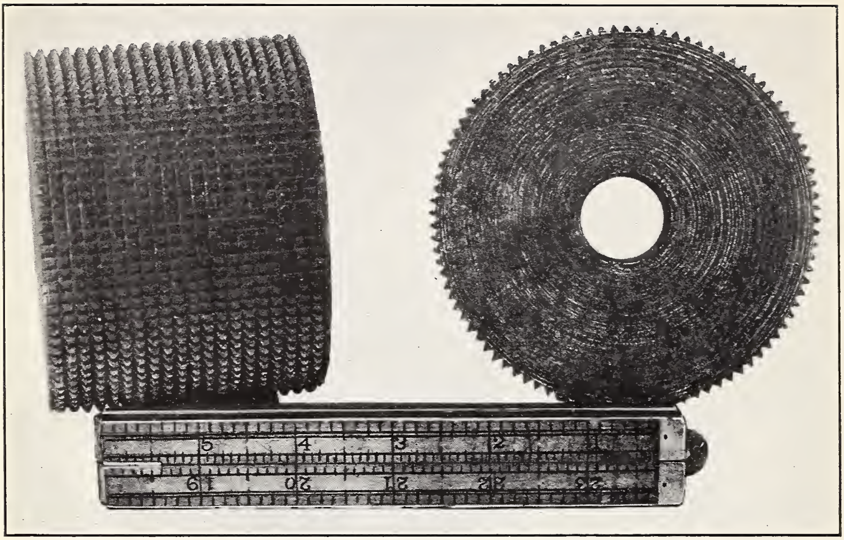

FIG. 1.—DIAMOND-POINT BURR, EIGHT TO THE INCH.

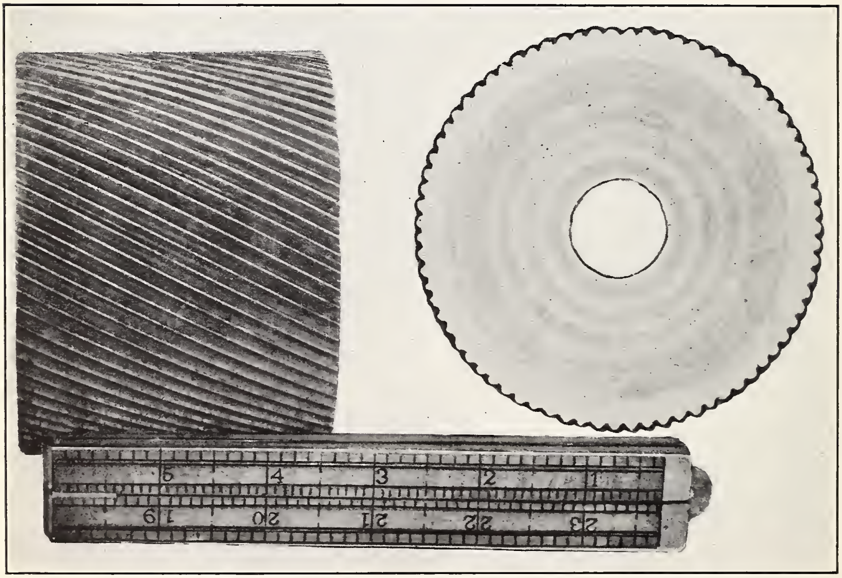

FIG. 2.—SPIRAL-CUT BURR, SIX TO THE INCH.

(Advance $1\frac{1}{2}$ inches in crossing 3-inch face.)

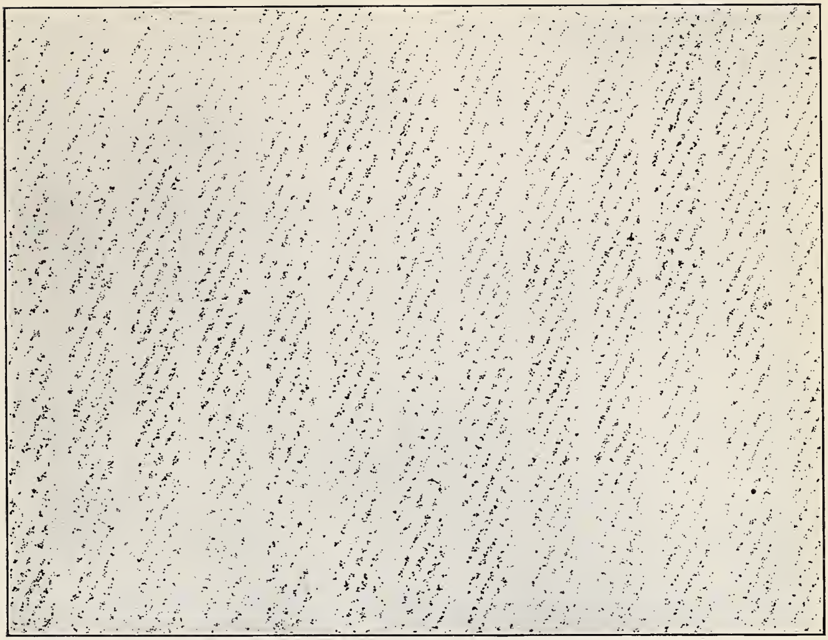

FIG. 1.—SURFACE OF STONE, FRESHLY DRESSED.

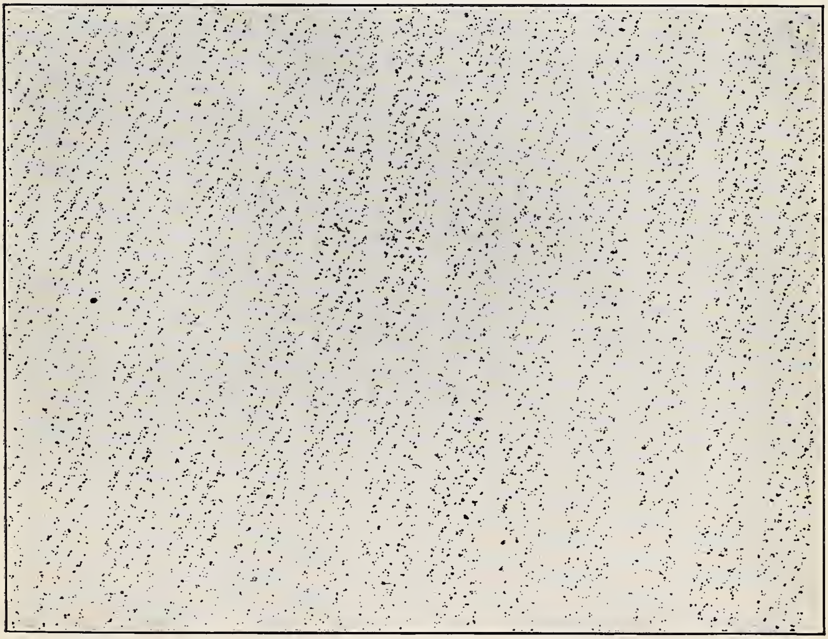

FIG. 2.—SURFACE OF STONE AFTER PRODUCTION OF 12.5 TONS OF PULP.

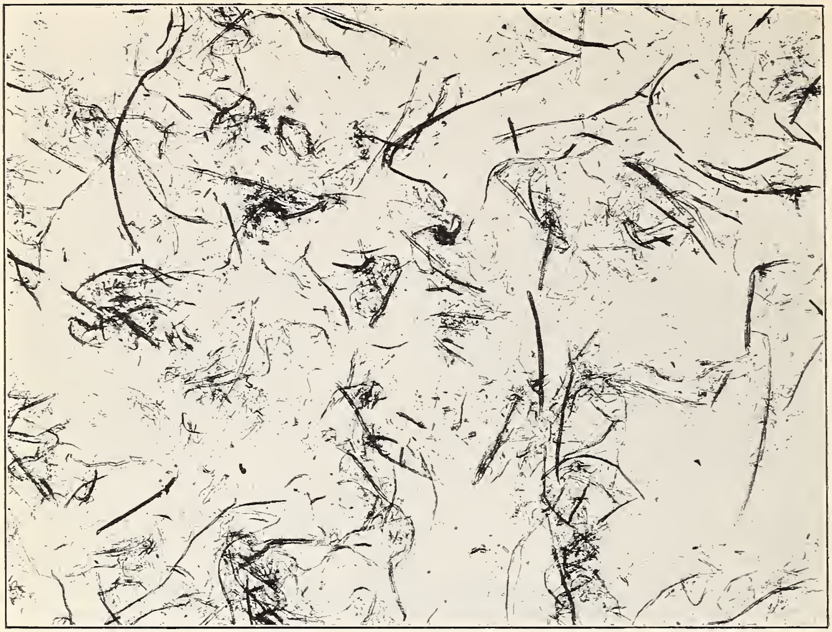

FIG. 1.—SHARP STONE, 64.5 HORSEPOWER PER TON.

FIG. 2.—DULL STONE, 84.5 HORSEPOWER PER TON.

COMPARISON OF SPRUCE PULPS GROUND ON SHARP AND DULL STONES.

(Magnified 15 diameters.)

representing approximately 50 horsepower per ton. This indicates that it is impossible, with the apparatus used, to produce pulp with less than 50 horsepower per ton in 24 hours, no matter what pressure or degree of sharpness is employed. When a low pressure is used, the influence of the condition of the stone on the horsepower consumption per ton is more marked than when higher pressure is applied. This is not the case with the consumption of power on the grinder and the production in 24 hours, which are affected by the surface of the stone to about the same extent at high and low pressures.

Figure 3 is a series of curves similar to those shown in figure 1, except that they were obtained at a speed of 225 revolutions per minute instead of 175 revolutions. The same general characteristics appear in this series as in the other. It is again evident that the curves showing the relation between sharpness of stone and power consumption converge at a point which has a value of approximately 50 horsepower per ton, the sharpness of stone being somewhat greater than the sharpest condition under which the tests were carried on.

Plate V is a reproduction of the surfaces of stone used in a number of tests. Figure 1 of this plate shows the surface before any grinding had been done, and figure 2 shows the same surface after 12.5 tons of pulp had been ground under various conditions of speed and pressure. In figure 1 the spiral markings are very distinct, while in figure 2 they are not as much in evidence, and at the same time the sand particles, represented by the black dots, are fewer in number. This is due to the fact that many of them have been broken or worn off. When grinding at 30 pounds pressure and 225 revolutions per minute, the rate of production for the first two hours after dressing was 3 tons of bone-dry pulp in 24 hours, and the power consumption per ton 112 horsepower. After 12.5 tons of pulp had been made and the stone had become dull the production fell to 1.89 tons in 24 hours, and the power consumption increased to 171.3 horsepower per ton for the same grinding conditions.

INFLUENCE ON YIELD AND QUALITY.

The condition of the surface of stone apparently has very little effect upon the yield per cord of wood. It is true that with extremely sharp stones more screenings are formed and possibly more fine fiber finds its way into the white water, but within reasonable limits of sharpness the yield shows little variation.

Plate VI shows two photomicrographs of pulp obtained on stones of different degrees of sharpness. In one case a consumption of 84½ horsepower per ton was necessary, while in the other only 64½ horsepower was required. The photographs indicate that a better quality of pulp is produced at the greater power consumption and lower degree of sharpness of the stone. The samples of paper made from

various experimental pulps show, when tested, that paper from pulp produced by the sharper stones has less strength than that from pulp ground on duller ones.

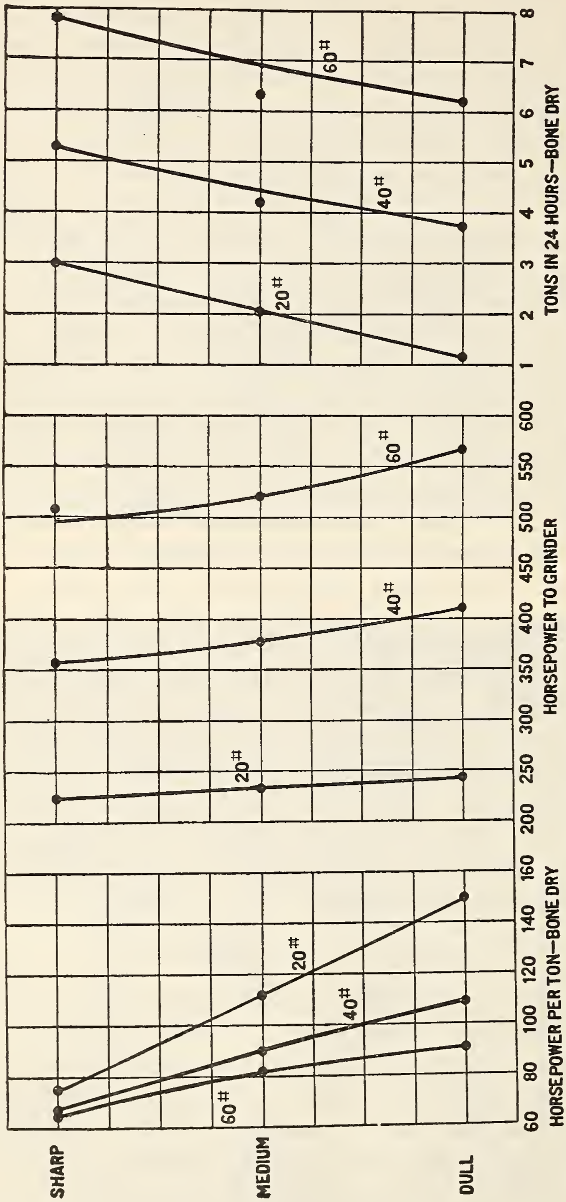

Fig. 3.—Relation of power consumption and rate of production to sharpness of stone, at 225 r. p. m. (Runs Nos. 6 to 8, 12 to 14, and 18 to 20, inclusive.)

In the tests conducted on stones sharpened so that the surface consisted of deep ridges or points and grooves, it was found that the quality of pulp produced was uniformly poor, consisting of very fine

fiber intermixed with coarser particles. When a very sharp surface is used, the wood fibers are literally ground to pieces; a larger percentage of screenings is also made, although not so large as might be expected. Under such conditions the fibers are ground so short and fine that it is almost impossible to remove the lap from the wet-machine press roll.

Deep grooving of the surface of the stone causes more rapid production of pulp, but at the sacrifice of quality. When high power without excessive sharpness of the stone is used, the grit of the stone comes more into play. In fact, the grit of the stone, more than any other factor, influences the quality of pulp produced under conditions of high power consumption.

PRESSURE ON GRINDER CYLINDERS.

For any given cylinder pressure, the pressure at which the wood is forced upon the revolving grindstone varies greatly with the diameter and length of the material. Besides, the wood may bind in the pockets, and this also results in a variation of the pressure on the stone. In commercial practice the pumps supplying the water to the grinder cylinders often do not have sufficient capacity, and, as a result, the pressure drops off each time one of the pistons is raised or lowered. In order to eliminate this effect some mills have installed triplex or centrifugal-pressure pumps which are directly connected to the grinder shaft. By this means the increased speed of the grinder brought about by raising one or more of the pistons results in increasing the speed of the pump, thus raising the pressure on the other cylinders of the grinder and reducing the speed of the stone to normal. This to some extent brings about a regulation of the speed, but causes a wide variation in the pressure. Because it is claimed that any change in the pressure results in a great change in the quality of the pulp, some manufacturers have provided their grinders with devices which are supposed to bring about uniform conditions of pressure. While it is undoubtedly true that the latter greatly influences quality, it is doubtful whether any appliance or apparatus thus far placed upon the market eliminates to a marked extent the variation of pressure of the wood on the pulpstone.

Though in the experiments discussed in this bulletin the pressure of the wood upon the stone varied, it is reasonable to suppose that the variation due to difference of length and diameter of the wood, binding of the wood in the pockets, and similar causes, has a fairly constant range for any cylinder pressure and consequently does not affect the deductions regarding the relative influence of different cylinder pressures upon production and power consumption.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 4 shows the relation of the pressure on the grinder cylinder to the horsepower per ton, power to the grinder, and production in

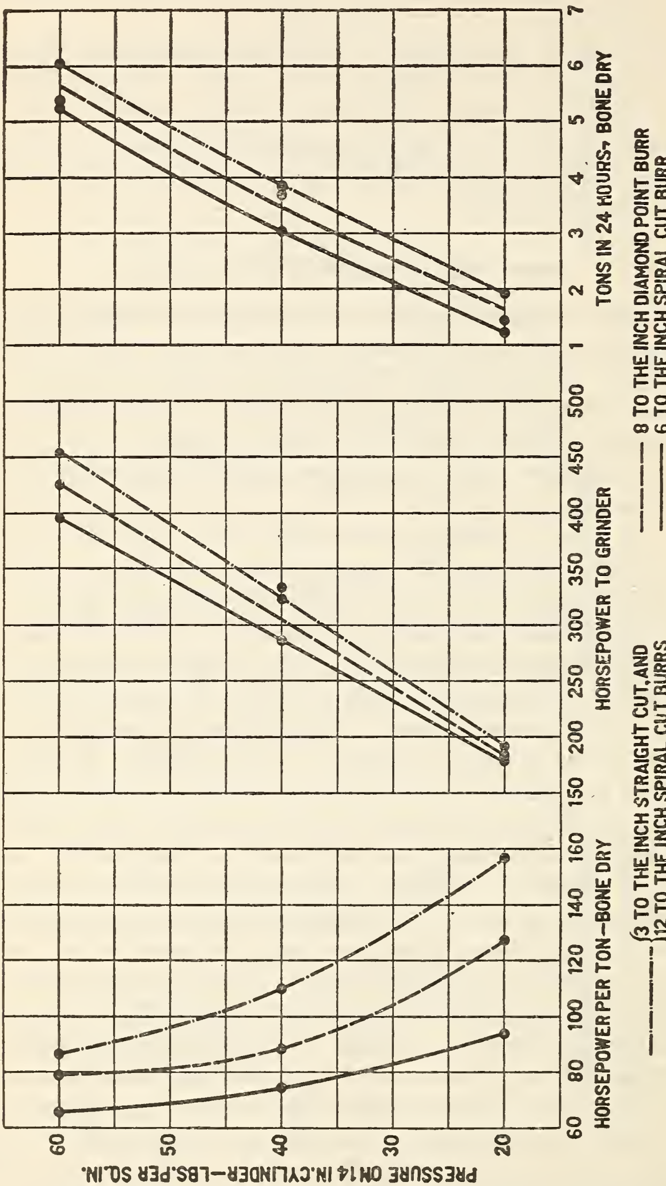

FIG. 4.—Relation of power consumption and rate of production to pressure at 175 r. p. m. (Runs Nos. 3 to 5, 9–1 to 11, and 15 to 17, inclusive.)

24 hours. The three curves represent surfaces of different degrees of sharpness and are plotted from the same data as those shown in figure 2. On the sharpest stone there is a very slight decrease in the

power consumption per ton with increasing pressure, and on the dullest one a marked decrease in power consumption as the pressure

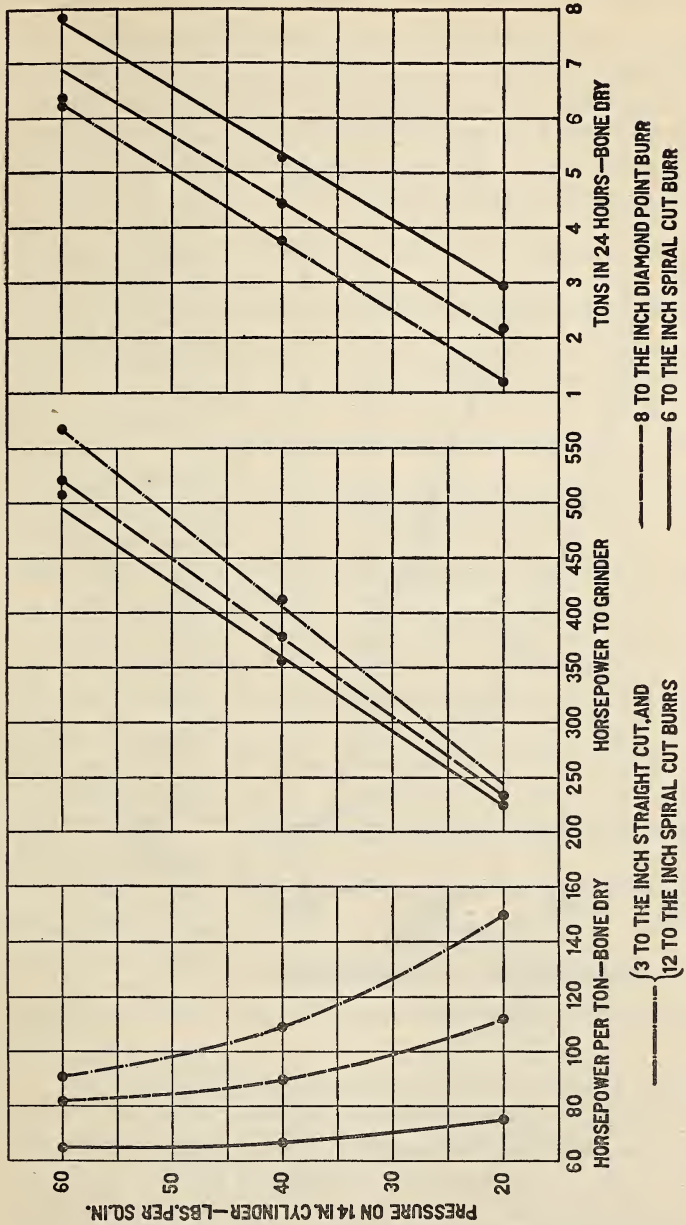

FIG 5.—Relation of power consumption and rate of production to pressure at 225 r. p. m. (Runs Nos. 6 to 8, 12 to 14, and 18 to 20, inclusive.)

is raised. The power to the grinder varies directly with the pressure on the cylinders; the same is true of the production in 24 hours.

The variation of the same factors at a speed of 225 instead of 175 revolutions per minute is shown in figure 5.

The relation between pressure on the grinder cylinder and a quantity, C, derived from the formula $C = \frac{H}{PS}$, where H is the average horsepower to the grinder, P, the pressure in pounds per square inch of pocket area, and S, the peripheral speed in feet per minute, is shown in figure 6. The quantity C is proportional to the coefficient of friction of wood on the stone under the conditions of speed and pressure of the tests. There is a gradual decrease in the value of C, as the pressure of grinding is raised. The values for horsepower per ton also decrease with higher pressures, as shown on the curves between pressure and horsepower consumption. Of the two curves given in this figure, one illustrates the variation of C with pressure when steamed wood was ground, and the other when untreated wood was used. The variation of the quantity C with factors other than pressure and condition of wood may be obtained from Tables 3 and 4.

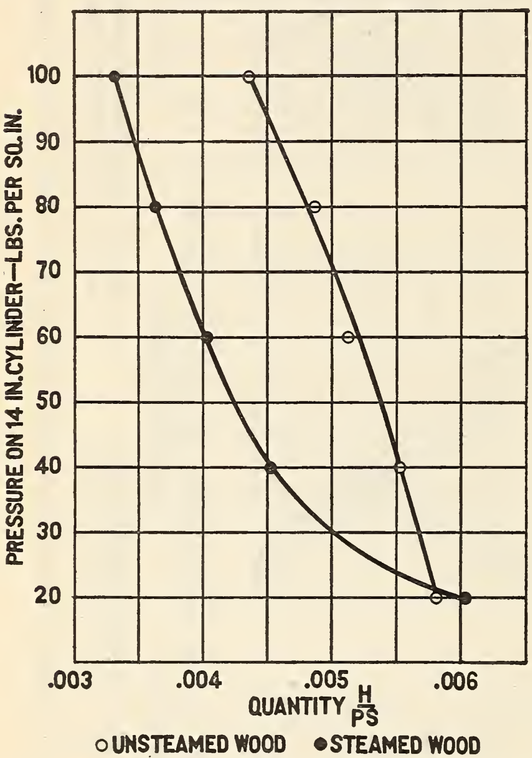

FIG. 6.—Relation of quantity $\frac{H}{PS}$ to pressure. (Runs Nos. 52 to 56 and 97 to 101.)

Figure 7 shows the relation of pressure on the grinder cylinders to power consumption per ton, power to the grinder, and production in 24 hours, when only two pockets on the grinder were used and the pressure was raised very high. The decrease in power consumption with increase in pressure is seen; the minimum value of the power consumption is approximately 55 horsepower per ton. As was shown in figures 4 and 5, the power to the grinder and production in 24 hours vary directly with the pressure on the grinder cylinder. It is interesting to note that under the same conditions of speed and surface of stone the horsepower to the grinder would be approximately 275 and the production 3 tons of bone-dry pulp in 24 hours if 40 pounds pressure were used, while if the pressure

were raised to 100 pounds per square inch the horsepower required by the grinder would be doubled, but the production in 24 hours would be more than trebled.

Figure 8 shows the relation between the number of pockets used and the horsepower consumption per ton of pulp. In this test the power to the grinder and the speed were maintained constant; the power was utilized by varying the grinder pressure according to the number of pockets used. When using one pocket and a pressure of 120 pounds per square inch the consumption per ton was 58 horsepower, while with three pockets and a pressure of 36½ pounds the power consumption per ton was approximately 89 horsepower. This is only another way of demonstrating that the power consumption per ton of pulp in 24 hours is much lower under conditions of high pressure of grinding than under conditions of low pressure. This test is of interest to manufacturers, because it suggests that by using a smaller number of pockets they can procure a larger quantity of pulp during times of low water without sharpening the stone to an unusual degree.

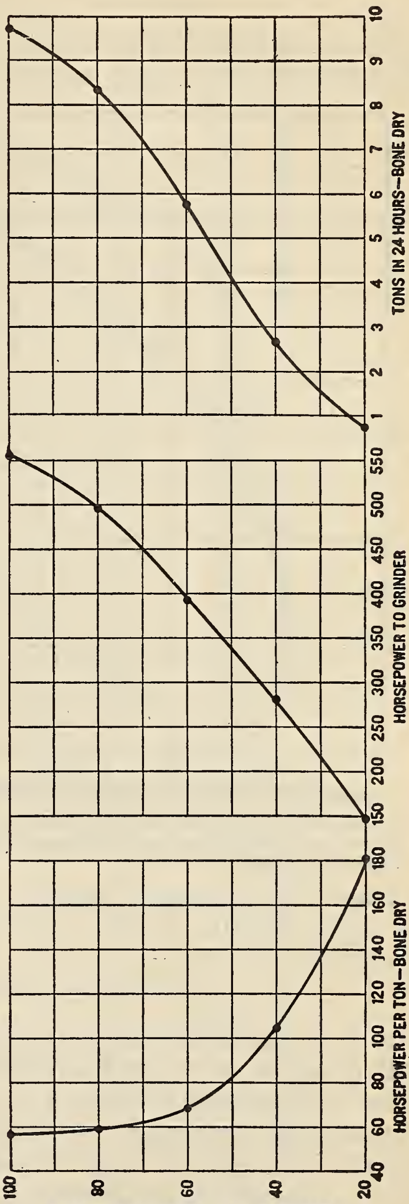

FIG. 7.—Relation of power consumption and rate of production to pressure at 225 r. p. m., 2 pockets. (Runs Nos. 52 to 56, inclusive.)

The relation of pressure on the grinder cylinder to horsepower per ton, horsepower to the grinder, and production in 24 hours when the wood was steamed prior to grinding is shown in figure 9. In this case the pressure has not nearly so marked an effect upon the various factors as it had in the tests shown in figure 7. The wood was

steamed for a period of six hours at 60 pounds pressure, and two pockets were used in the grinding.

INFLUENCE ON YIELD AND QUALITY.

Figure 10, which shows the relation between yield per hundred cubic feet of solid rossed wood and the pressure on the grinder cylinder, indicates that with increasing pressure the yield of pulp increases. Although the amount of screenings also increases, there is a gain in the yield of screened pulp at high pressure, due to the smaller quantity of pulp in the white water. The increase was approximately 11.5 per cent in the tests on which this figure is based.

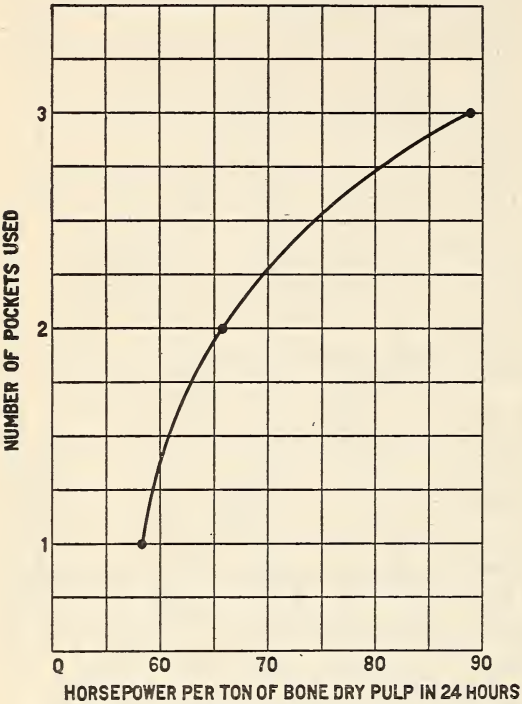

FIG. 8.—Relation of power consumption to number of pockets used at 225 r. p. m., 330 horsepower to grinder. (Runs Nos. 120 to 122, inclusive.)

The effect of pressure on the quality of pulp, as indicated by the strength of the paper, is shown by figure 11. The strength factor, or the bursting strength per square inch divided by the weight per ream, decreases with increasing pressure. The decrease in the strength of the paper with the power consumed in making a ton of pulp is also shown.

PERIPHERAL SPEED OF STONE.

In most commercial plants the peripheral speed of stone is given little attention, and perhaps rightly so. When the pressure on a pocket of the grinder is removed the speed will increase greatly unless controlled by a governor. The effect of this increased speed is generally more beneficial than otherwise, since it prevents, to some extent, a decrease in the production of pulp with the smaller number of pockets in operation. There are conditions of operation which require a fairly constant speed, and the use of a governor is therefore desirable, especially when the peripheral speed is high. It is easy to

see that the removal of the pressure from a pocket, especially if a very high one were being carried, might so relieve the stone that the speed

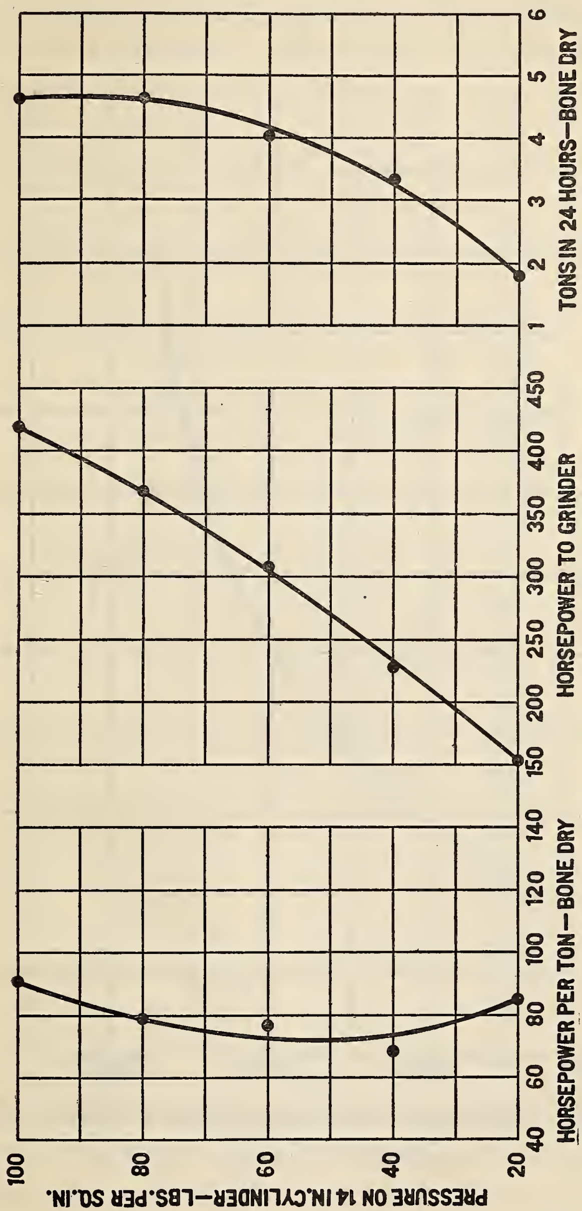

FIG. 9.—Relation of power consumption and rate of production to pressure at 225 r. p. m., 2 pockets, steamed wood. (Runs Nos. 97 to 101, inclusive.)

would increase to a dangerous degree. However, stones are generally operated considerably below their bursting speeds.

INFLUENCE ON THE POWER CONSUMPTION AND RATE OF PRODUCTION.

Figure 12 shows that the power to the grinder varies directly with the speed, as does also the production in 24 hours, but to a greater extent. This results in a lower power consumption per ton with

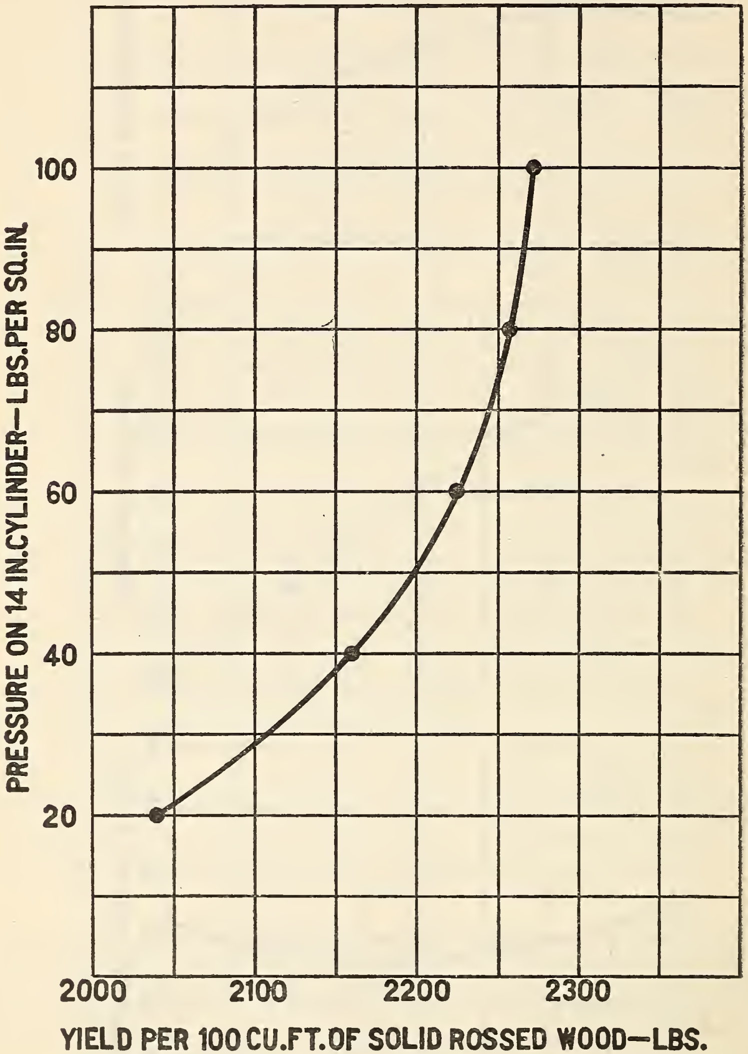

FIG. 10.—Relation of yield to pressure, 225 r. p. m., 2 pockets. (Runs Nos. 52 to 56, inclusive.)

increase of speed. In these tests the pressure was maintained constant.

In the tests plotted in figure 13 the power to the grinder was maintained as nearly constant as possible, and both the pressure and speed were varied, though so adjusted as to utilize the power in each case.

With constant power to the grinder the production in 24 hours is practically constant, regardless of whether the pulp is produced at low pressure and high speed or at high pressure and low speed, although there seems to be a very slight decrease in the production at low speed and high pressure. This effect is seen more clearly in the

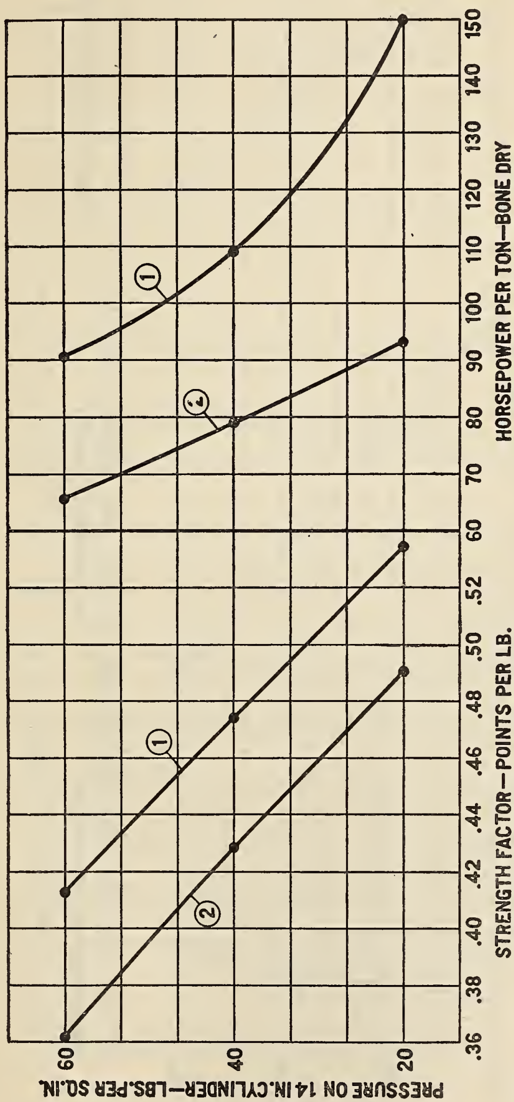

FIG. 11.—Relation of strength of paper and power consumption to pressure at 175 r. p. m. (1) and 225 r. p. m. (2). (Runs Nos. 6 to 8, and 9-1 to 11.)

curve for horsepower per ton. While the power consumption per ton of pulp is practically constant, there is a slight increase as the pressure increases and the speed decreases. In commercial practice the grinders ordinarily receive a certain amount of power direct, and

it was thought that pressure and speed could be so combined as to secure a maximum production of pulp from the power supplied to the

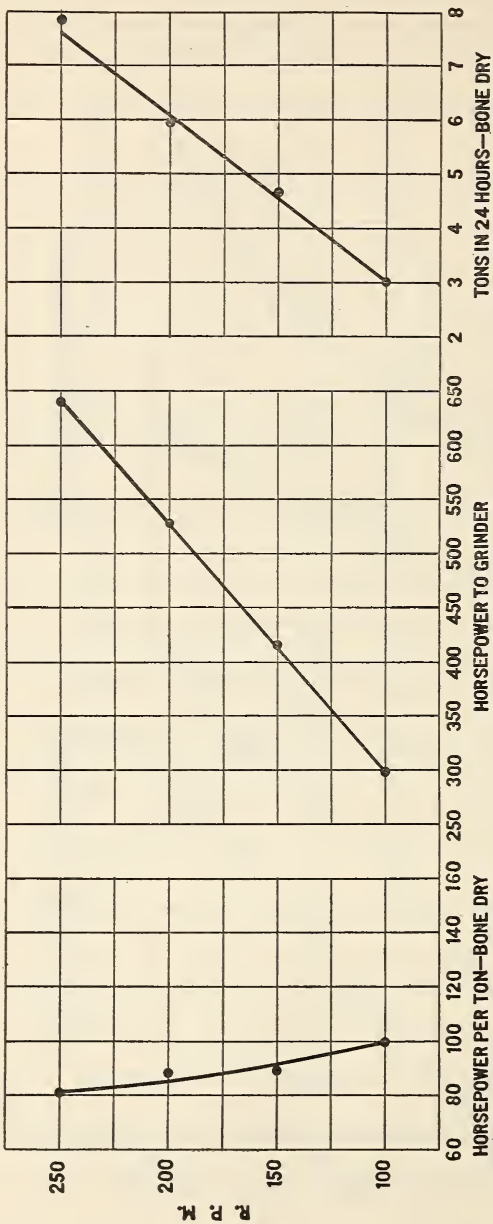

FIG. 12.—Relation of power consumption and rate of production to speed at 60 pounds pressure. (Runs Nos. 24 to 27, inclusive.)

grinder. This, however, did not prove to be the case, since in the range covered in the tests the production was practically constant.

INFLUENCE ON YIELD AND QUALITY.

The yield per cord and quality of pulp are only slightly influenced by the speed. The yield appears to be somewhat higher with high

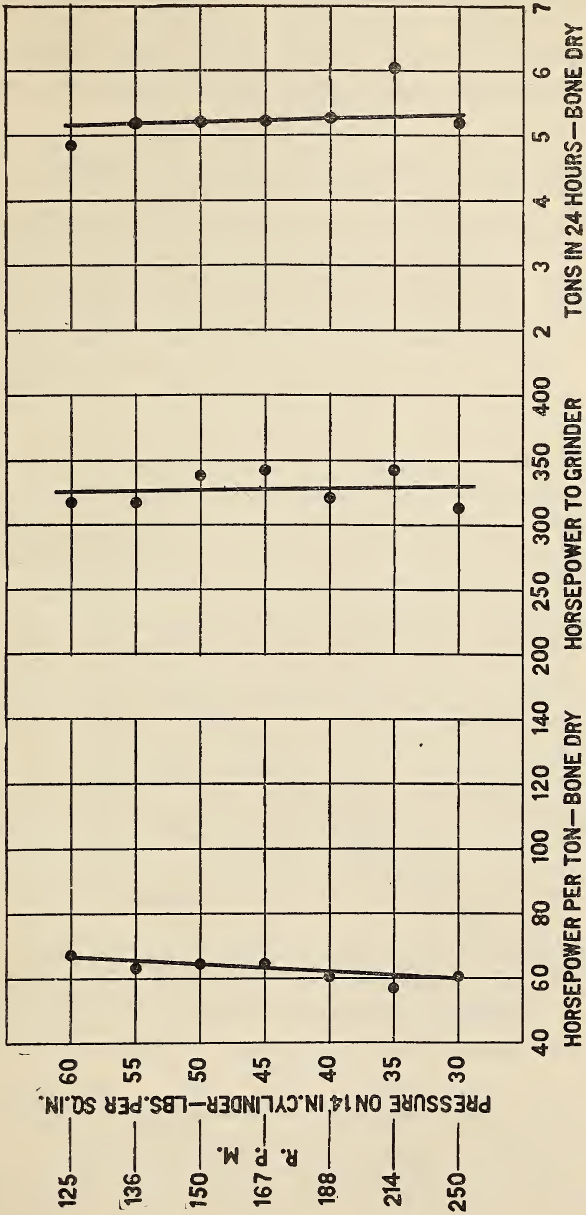

FIG. 13.—Relation of power consumption and rate of production to pressure and speed; 330 horsepower to grinder. (Runs Nos. 32 to 38, inclusive.)

speed; the difference, however, is small. The quality as determined by strength tests of the papers is not influenced so much by speed as

by pressure of grinding. There is, however, an increase of strength with decrease of speed.

The relation of speed and of pressure to strength by Mullen test in points per pound is shown in figure 14. The tests on which this curve is based are the same as those shown in figure 13. The strength of the paper is greater, the power to the grinder being constant, when the pulp is produced at high pressure and low speed than when it is produced at low pressure and high speed.

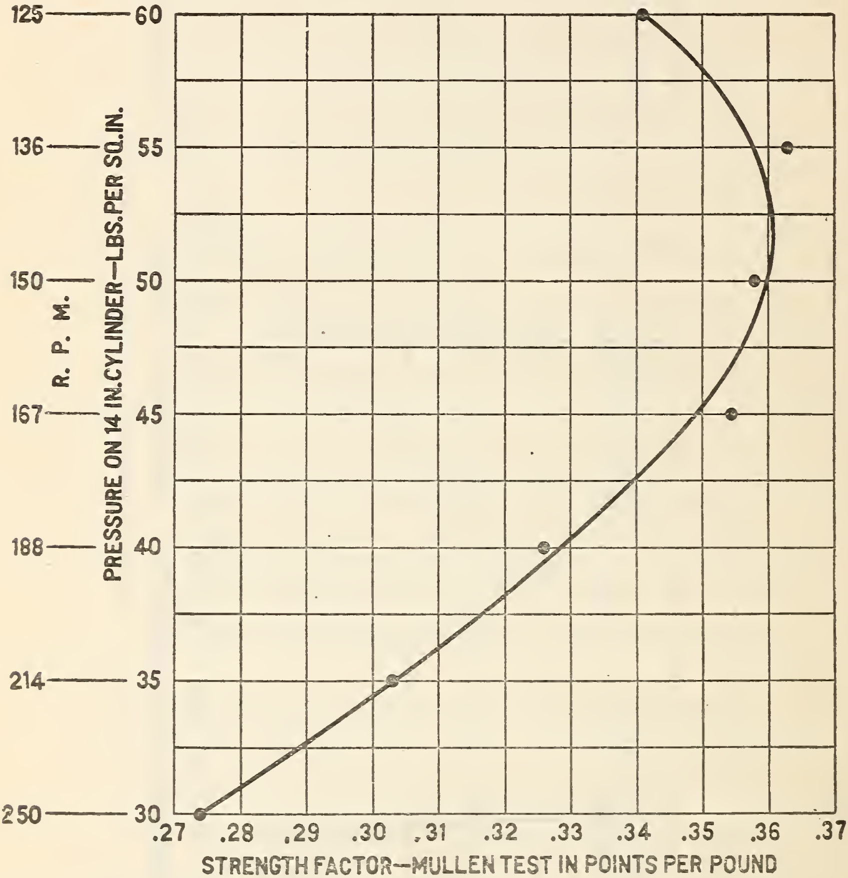

FIG. 14.—Relation of strength factor to speed and pressure; 330 horsepower to grinder. (Runs Nos. 32 to 38, inclusive.)

TEMPERATURE AND THICKNESS OF STOCK IN THE GRINDER PIT.

The effect of the temperature at which mechanical pulp is produced has long been the cause of a difference of opinion between American and European manufacturers. American paper-making practice requires in almost all cases the production of ground wood at high temperature, and it is claimed that pulp so produced has stronger

and longer fibers and is considerably tougher than cold-ground pulp and works "freer" on the machine. On the other hand, it is claimed that cold-ground pulp is finer, freer from shives, that it gives a better "closed" sheet of paper, and has greater opacity than hot-ground pulp. These points, however, are difficult to prove or disprove. A number of tests were run to determine the effect of cold grinding upon factors of economic production, but most of the experiments were made by the hot-grinding process.

The thickness of pulp in the grinder pit is another factor which is claimed to have an important influence on the paper produced. Many manufacturers run their pulp extremely thick, while others run it comparatively thin. Some claim that a stone will not clean itself unless the stock is very thick, and that, as a result, there will be more or less regrinding of the pulp with thin stock. The tests discussed in this report were conducted, for the most part, with thick stock in the grinder pit.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

Table 3 (tests Nos. 39 to 50, 133 to 136, and 155 to 158) contains data secured under conditions of hot and cold grinding and shows that varying the temperature from cold to hot has little effect upon the power consumption or power to grinder, but the production in 24 hours is somewhat higher under conditions of hot grinding. Table 1 gives the amount of power required to rotate the grinder at various speeds without load, but with stock of different consistency in the grinder pit. To overcome the friction of the pulp and bearings of the grinder when a thick stock was employed, from 12.4 to 18.7 kilowatts were required; with a very thin stock in the grinder pit from 2.7 to 10 kilowatts were needed. A maximum difference of 14.5 kilowatts between the power required for thick and for thin stock in the grinder pit occurred at 175 revolutions per minute. This amount of power, when calculated to the basis of power consumption per ton of pulp, becomes negligible.

TABLE 1.—*Power to the grinder in kilowatts at different speeds, without load, with thick and thin stock in the pit.*

Condition of stock.	Power to grinder.						
Revolutions of stone per minute	100	125	150	175	200	225	250
	Kilowatts.	*Kilowatts.*	*Kilowatts.*	*Kilowatts.*	*Kilowatts.*	*Kilowatts.*	*Kilowatts.*
Thick	12.4	14.9	16.3	18.7	14.0	14.0	15.3
Thin	2.7	3.4	3.1	4.2	6.0	8.0	10.0
Difference	9.9	11.5	13.2	14.5	8.0	6.0	5.3

INFLUENCE ON YIELD AND QUALITY.

The temperature of grinding and thickness of stock in the grinder pit do not influence the yield per cord of wood. The quality of pulp, however, is affected. The pulp produced at high temperature is long fibered, while a fine-fibered pulp is more easily secured by the cold-grinding process.

Table 5 (tests Nos. 39 to 50, 133 to 136, and 155 to 158) gives daat of tests of paper made from pulp manufactured at different temperatures. It appears that the temperature has very little influence on the properties determined by these tests.

PHYSICAL CONDITION OF THE WOOD.

The question of the influence of the physical condition of the wood is a very important one. Wood for pulp is almost invariably allowed to season for a long period before it is used, and as a result there is considerable loss due to rotting, and the wood becomes darker in color. It is more difficult to secure a long-fibered pulp from wood which has been seasoned for a long period than from green material. The treatment of wood by steaming, boiling, or some similar process prior to grinding is important, because by such treatment better fibers can be obtained than when woods are ground without treatment. This makes possible the use of woods which, if ground in the natural state, would yield very short-fibered pulps. In this way, too, pitchy woods can be made usable by the mechanical process.

In commercial practice it often happens that wood is ponded for a long time before it is ground. Unfortunately, wood of this kind was not available for test.

INFLUENCE ON POWER CONSUMPTION AND RATE OF PRODUCTION.

It was shown in figure 9 that when the wood had been steamed prior to grinding for six hours at a steam pressure of 60 pounds per square inch, the horsepower consumption per ton varied but slightly with variation in pressure. There is a decided contrast, however, in the forms of the curves of power consumption and rate of production obtained on untreated and steamed wood, as may be seen in figure 15.

The relation of the pressure on the grinder cylinders to the horsepower consumption per ton, horsepower to grinder, and the production in 24 hours, when green, seasoned, and steamed woods were ground is shown in figure 16. At low pressures the power consumption per ton of pulp is higher for seasoned wood than for steamed wood, while at high pressures the reverse is true. For green wood the average power consumption is lower than for either seasoned or steamed material. The power to the grinder for either seasoned or green wood under like conditions of speed and pressure is practically the same,

but it is less for steamed wood. This is due, undoubtedly, to the more slippery condition of the steamed material. The rate of production of

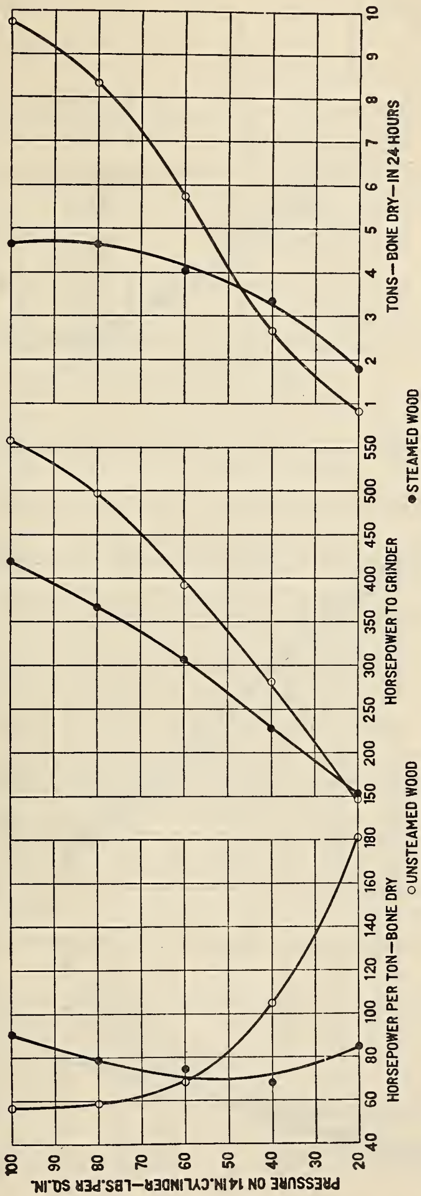

FIG. 15.—Comparison of variation of power consumption and rate of production with pressure at 225 r. p. m.; steamed and unsteamed wood. (Runs Nos. 52 to 56 and 97 to 101, inclusive.)

pulp from green wood is more rapid than from either seasoned or steamed wood.

INFLUENCE ON YIELD AND QUALITY.

Figure 17 shows graphically the weight per cubic foot of various woods and the yields secured from them under like conditions. The

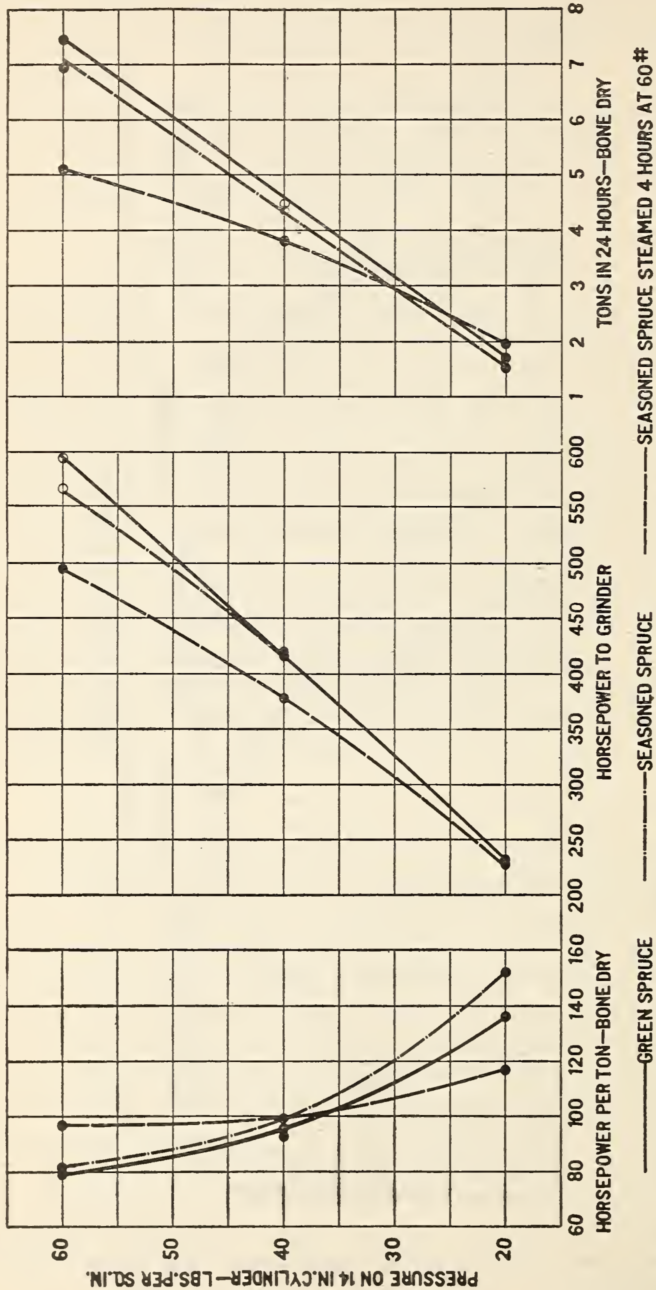

FIG. 16.—Comparison of variation of power consumption and rate of production with pressure at 225 r. p. m., green, seasoned, and steamed wood. (Runs Nos. 124 to 132, inclusive.)

woods tested had been steamed for a period of six hours at a pressure of 60 pounds. The species, with numbers corresponding to those in the figure, were:

1. Western yellow pine (*Pinus ponderosa*).
2. Lodgepole pine, Montana (*Pinus contorta*).
3. Western larch (*Larix occidentalis*).
4. Lodgepole pine, California (*Pinus contorta*).
5. White spruce (*Picea canadensis*), normal growth.
6. Red fir (*Abies magnifica*).
7. Aspen[1] (*Populus tremuloides*).
8. Balsam fir (*Abies balsamea*).
9. Jack pine (*Pinus divaricata*).
10. Hemlock (*Tsuga canadensis*).
11. Tamarack (*Larix laricina*).
12. Paper birch[2] (*Betula papyrifera*).
13. Sitka spruce (*Picea sitchensis*).
14. Western hemlock (*Tsuga heterophylla*).
15. White spruce (*Picea canadensis*), rapid growth.

The yields are almost directly proportional to the bone-dry weight of the wood per cubic foot. In the same figure the relation between yield and dry weight is shown when unsteamed wood was used. In this case also the two factors vary directly.

The yield of pulp per 100 cubic feet of solid wood appears to be approximately the same from seasoned and green wood. It is very probable, however, that on the basis of a cord of rough wood the yield would be smaller for seasoned material on account of the decayed portions. The yield of pulp from steamed wood is a great deal lower than from seasoned or green material. This may be due to the solvent action of hot water on wood, and the assumption is strengthened by the fact that the yield becomes less as the treatment is prolonged or the steaming pressure raised. The relation between yield and duration of treatment is shown in figure 18. It is probable also that the yield from ponded wood is lower than from dry or green wood, on account of the dissolving action of the water.

The quality of the pulp does not seem to be influenced greatly by the moisture content of the wood or weight per cubic foot. However, by treating the wood prior to grinding the strength is much increased and the color darkened. Therefore, when strength is the important factor steaming prior to grinding raises the quality of the pulp, but when light color is one of the chief considerations the quality is greatly lowered.

Plate VII shows two photomicrographs of pulp produced under the same conditions; the one from wood which had been previously steamed, and the other from unsteamed wood. The effect of steaming is readily discernible in the appearance of the fiber.

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[1] Generally called "popple" in Wisconsin.

[2] Generally called white birch in Wisconsin.

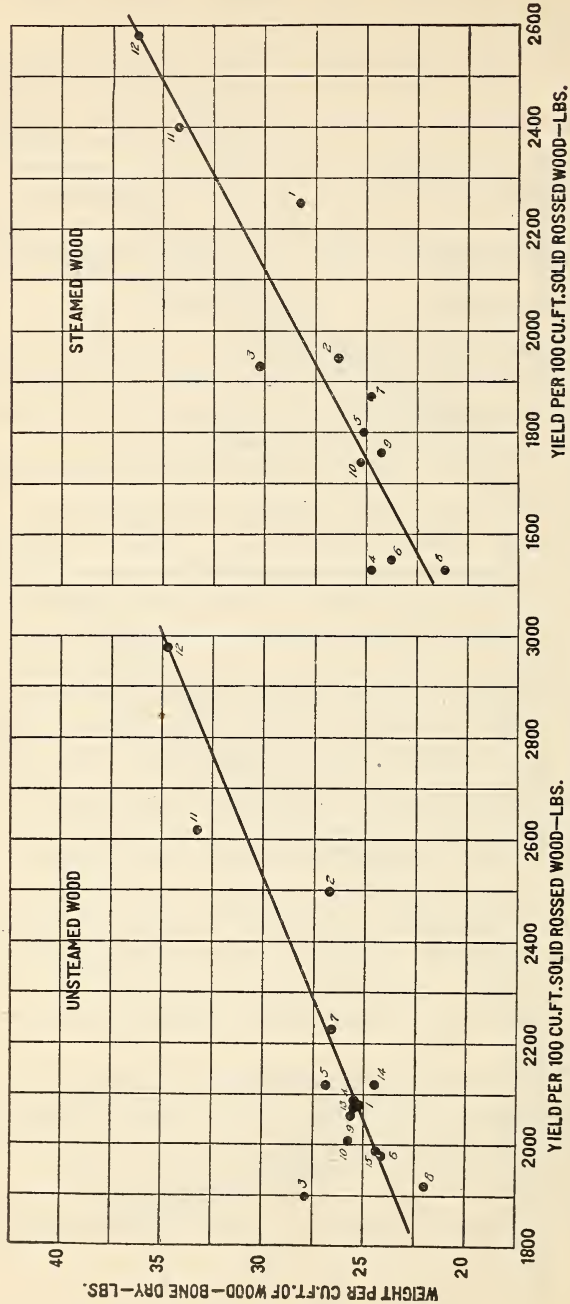

Fig. 17.—Relation of yield to dry weight of wood, steamed and unsteamed.

FIG. 1.—STEAMED WOOD, 220 HORSEPOWER PER TON.

FIG. 2.—UNSTEAMED WOOD, 89.9 HORSEPOWER PER TON.

COMPARISON OF SPRUCE PULPS MADE FROM STEAMED AND UNSTEAMED WOODS.

(Magnified 15 diameters.)

OTHER FACTORS.

POWER CONSUMPTION PER UNIT OF STRENGTH.

Figure 19 shows the effect of the consumption of different amounts of power on the strength of paper made from the experimental pulps. It is evident that, under the present methods of manufacturing mechanical pulp, the utilization of a considerable amount of power is necessary to obtain a strong paper. The paper increases in both tensile and bursting strength with the power consumption, although not uniformly. The indications are that a maximum value of strength will be obtained at some value of power consumption, and that above this value the strength will decrease.

A factor of great importance in commercial manufacture is the power consumption per ton per meter of breaking length of paper, or, as it might also be expressed, the power consumption per ton, per point, per pound test. By dividing values of power (fig. 19) by the corresponding values of strength, results are obtained which indicate that for each horsepower expended in the manufacture of pulp at low-power consumption a greater degree of strength is obtained in the resultant paper than for a horsepower expended under conditions of high-power consumption. This fact suggests that maximum efficiency in the production of a mixed ground wood and sulphite paper of a given strength requires the proper adjustment of both the power consumption of the grinder and percentage of sulphite in the mixture. For instance, it might be desirable to use a small amount of power per ton of pulp and a relatively high proportion of sulphite, rather than a higher power consumption and lower proportion of sulphite. The proper adjustment would depend, of course, on the relative value of ground wood produced by high and low power and sulphite fiber.

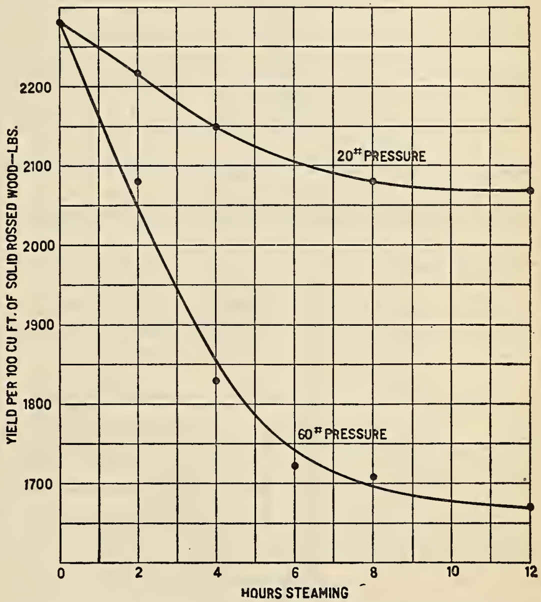

FIG. 18.—Relation of yield to length of time wood was steamed prior to grinding. (Runs Nos. 103 to 107 and 114 to 119, inclusive.)

SIZE OF BOLTS AND RATE OF GROWTH.

The diameter and rate of growth of the wood have very little effect upon either the power consumption or rate of production. The rate of production decreases slightly when wood of medium diameter

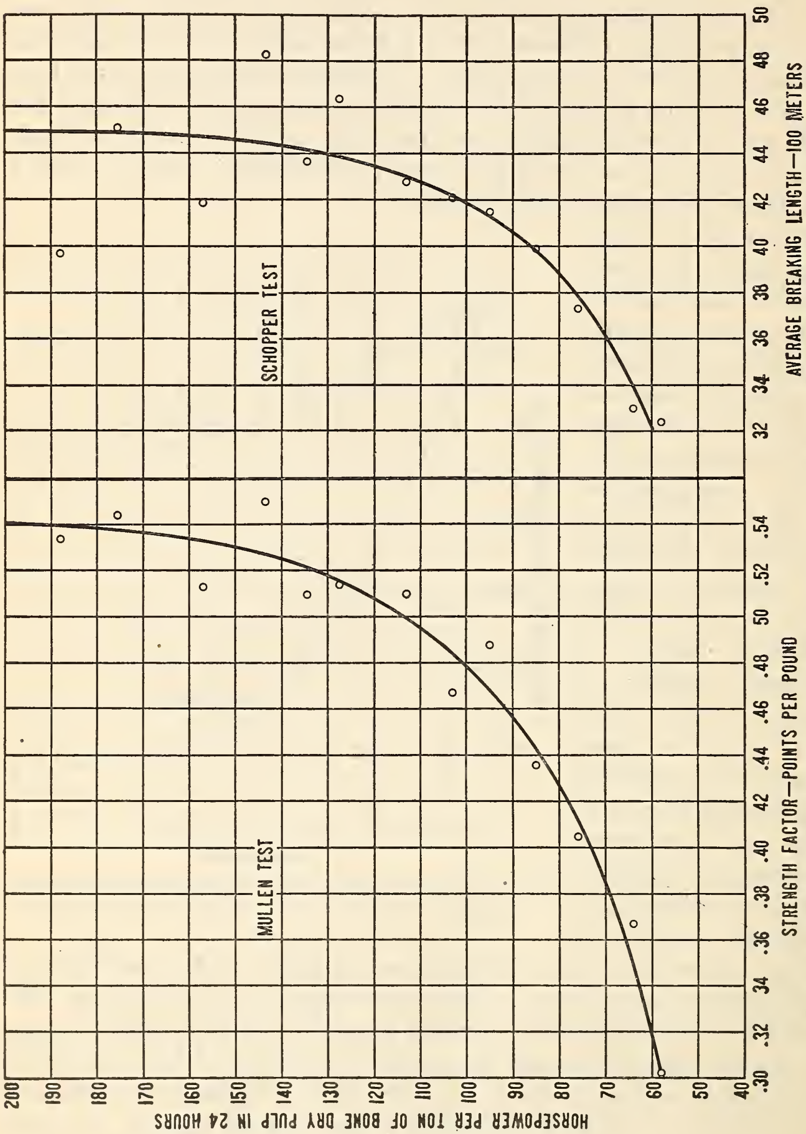

FIG. 19.—Relation of strength of paper to power consumption per ton of pulp. (Averages of all runs made.)

(6 to 8 inches) is used. This is due to the fact that in order to fill the pockets some of the wood must be split, which causes more or less binding.

The yield and quality are both influenced by the rate of growth of the wood. The yield is considerably lower from wood of rapid growth than from wood which has grown slowly. The pulp is softer when rapid-growth wood is used, although the strength is practically the same.

EFFICIENCY OF CONVERSION.

The efficiency of converting rossed wood into pulp under ordinary commercial conditions averages approximately 88 per cent. This leaves 12 per cent of the weight of the wood to be accounted for in either screenings or white-water, or as water-soluble material. From about 2 to 7 per cent is lost in screenings and white-water as wood fiber; the remainder, 5 to 10 per cent, must be in the white-water as soluble or insoluble organic or inorganic materials. The wood when ground is in a very finely divided state and may be acted upon quite readily by the water with which it is mixed. It is reasonable to suppose that the dissolved portion would be greater under conditions of extremely hot grinding than when the cold-grinding process is used. Likewise, there would be a greater loss when the pulp remains in contact with water for a considerable period than there would be if it were immediately run out on the wet machine.

CONCLUSIONS.

From the results of the experiments the following general conclusions are drawn:

(1) The power to grinder increases with speed and pressure of grinding and decreases with the degree of sharpness of stone. There is also a very slight increase in the power required with increase of temperature, other conditions remaining constant, while the thickness of stock in the grinder pit has almost no influence. With all other conditions similar the power to the grinder is less for steamed wood than for green or seasoned wood untreated.

(2) The rate of production varies directly with pressure, speed, and degree of sharpness of the stone. Less pulp is obtained in 24 hours with seasoned wood than with green, and still less with steamed wood, all other conditions being the same. The temperature and thickness of stock in the grinder pit have little influence on the rate of production. Slightly less pulp is produced at low temperatures.

(3) The horsepower consumption per ton, when untreated wood is ground, increases as the pressure decreases, according to a fairly definite law. It is lower on sharp stones than on dull ones and increases as the speed decreases. There is, however, not as much difference between the power consumption per ton at low speed and high speed as there is between power consumption at low pressure and high pressure. The power consumption is very little influenced

by temperature, but it is slightly lower at high temperature. The power consumption is higher for seasoned than for green wood, and higher for steamed wood than for either seasoned or green material ground under the same conditions.

(4) The yield of pulp per cord is greater at high pressure than at low, and while this is true also of the screenings there is not as much fine material lost in white water when high pressure is used. The yield is not greatly influenced by the surface of the stone, but it is slightly higher at high speed than at low. The yield is proportional to the bone-dry weight per cubic foot of wood.

(5) The quality of pulp varies most with the surface of the stone, less with the pressure, and least with the speed. The weight per cubic foot and character of wood, especially the latter, influence quality to a marked extent. Temperature also has a marked influence. Pulp of greater strength is obtained at higher temperature; that produced at low temperature will take a better finish. Pulp of better color can be obtained from green wood than from seasoned, and stronger pulp can be obtained by cooking the wood prior to grinding. The quality of paper produced under exactly the same conditions, but made of pulp produced at different grinder pressures, varies directly with the grinder pressure and the horsepower consumption per ton of pulp. Mechanical pulp of greatest strength can be produced only by the use of a relatively large amount of power.

SUMMARY OF DATA.

A summary of the experimental data upon which the results given in this bulletin are based is given in Tables 3, 4, and 5. Tables 3 and 4 show the grinding conditions and resultant factors for untreated and for steamed wood, respectively. Table 5 gives the results of the quality test on the pulps and on the papers manufactured from them.

The following explanations apply to quantities given in Tables 3 and 4:

"Average horsepower to grinder." This is obtained by a watt-hour meter, and represents the actual consumption of power.

"Maximum horsepower to grinder." This is obtained from a recording wattmeter and represents the maximum power required by the grinder for one minute or longer at any time during the test.

"Efficiency of conversion." The efficiency of conversion is a factor obtained by dividing the yield per 100 cubic feet of solid rossed wood by the bone-dry weight per 100 cubic feet of the wood ground.

"Horsepower consumption per ton of bone-dry pulp in 24 hours." The power consumption per ton is calculated by dividing the average horsepower to the grinder by the production of bone-dry pulp in 24 hours.

The methods of computing results of the tests is explained more fully in the Forest Service publication, Experiments with Jack Pine and Hemlock for Mechanical Pulp.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp.*

Number of mill.	Make of grinder.	Number of grinders.	How driven.	Number of pockets.	Pocket area.	Diameter of cylinders.	Approximate horse-power to grinder.	Pressure on cylinders.	Equivalent pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Stone. Kind.	Stone. Diameter.	Stone. Width of face.	Stone. Revolutions per minute.	Stone. Peripheral speed.	Temperature of grinding.	Kind of burr.	Approximate horse-power per ton.	Size of screen slots or perforations.	Kind of paper produced.
					Sq. in.	*In.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs.*		*In.*	*In.*		*Ft. per min.*	*°F.*			*In.*	
1	A			3		20		35	71.4		C	54	27	200	2,830	162	Straight cut, 7 to inch.	55		News, manila, and hanging.
2		6		2	168	12	500 275	60	44.1	40.4		54 52	27 25	200	2,830 2,724					Tag, manila, and special paper.
3	A	2		3	336	16	300	35	45.7	20.95		52	26	150	2,043					Manila, fiber, and colored specialties.
4	B	7	Direct connected to water wheels.				144										Straight cut, 7 or 8 to inch, solid steel burr.			Wood-pulp board.
	C	1	do.	3		16	300	50	65.4		A	54	28	205	2,900			65	0.014	Do.
5	D	1	Geared to water wheels.	3		18	400	45	73.4		B	54	27	145	2,052		Diamond point, 6 to inch.		.010	News.
6	D	2	do.	3		10	300	65	33.2		C	54	27	219	3,100	140	Straight pick, 8 to inch.	31	.010	Do.
7		2		3	144	14	500	50	50	53.5		54	28	200	2,830					Tag, manila, and special papers.
8	E	2	Geared to water wheels.	3		16	300–350	40	52		B and D.	54	26	190–200	2,688–2,830	175	Solid spiral cut, 8 to inch.	75	.012	Poster, tag board, and manilas.
	A	1	do.	3		16		40	52.3		do.	54	26							
9	F	2	Direct connected to water wheels.				300–400													Color wrapping, and fiber.
10	A	2	do.			16	400	45–50	58.9–65.4		B	52	27	225	3,064		Diamond point, 7 to inch.	75	.012	Tissue and light weight manila.
	E	1	do.				500													
11	G	1	Geared to water wheels.	3			450													
13		5	Direct connected to water wheels.															70		News and bag.
		1	Motor driven				300													

NOTE.—The characters given in the columns "Make of grinder" and "Kind" of stone indicate, respectively, which mills used the same grinder and the same stone. The actual make of the grinders and kind of stones is not given.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—Continued.

Number of mill.	Make of grinder.	Number of grinders.	How driven.	Number of pockets.	Pocket area.	Diameter of cylinders.	Approximate horse-power to grinder.	Pressure on cylinders.	Equivalent pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Stone. Kind.	Stone. Diameter.	Stone. Width of face.	Stone. Revolutions per minute.	Stone. Peripheral speed.	Temperature of grinding.	Kind of burr.	Approximate horse-power per ton.	Size of screen slots or perforations.	Kind of paper produced.
					Sq. in.	*In.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs.*		*In.*	*In.*		*Ft. per min.*	*°F.*			*In.*	
14	B and C	....	Belted to steam engine.	3	......	14	....	40	40	.....	A	54	27	190	2,688	80-90	Cast steel, 5 and 6 teeth to inch; 5-inch diameter by 3-inch pick.	85	1/64	News, book.
15	H	8	Direct connected to water wheels.	3	......	10	250	80	40.8	.....	A	52	24	250	3,405	100-150	Diamond point, 6 to inch.	70	0.011	News and hanging.
16	D	4	do	3	......	14	350	40	40	.....	C	54	27	190-200	2,688-2,830	Hot.	do	75	....	News.
	H	15	do	3	......	7	135	70	17.5	.....	C	52	19	195	2,660	do.	do	....	....	
17	L	14	do	3	......	16	450	45	58.9	.....	B	50	27	220	2,880	130	Diamond point, 9 to inch.	75	.075	News, book, railroad writing.
12	....	....	Geared to water wheels.	....	......	....	400	.....	....	.....	....	......	....	......	....	......	....	....	....	News.
18	A	4	....	2	168	16	150	20	26.2	24.00	....	54	26	80	....	......	....	....	....	Bag and tissue.
19	E	3	Direct connected to water wheels.	3	......	16	400	40	52.3	.....	B	54	27	195	2,760	150	Straight cut, 7 to inch.	70	.072 .016	Bag, wrapping, and fiber paper.
20	....	6	Electric drive	3	......	14	300	50	50	.....	....	......	....	247	....	......	....	....	....	Catalogue and light-weight news.
	....	3	Direct connected to water wheels.	3	......	14	300	50	50	.....	....	......	....	210	....	......		....	....	
21	K	2	do	3	......	16	125	12	17	.....	A	54	27	250	3,540	150	Straight cut, 5 or 6 to inch.	65	.010	No. 1 news or No. 3 book.
22	B	2	Belted	1	......	8	125	80	26.1	.....	D	50	25	170	2,225	60	Straight cut, 2⅔ to inch.	...	.013	Cheap bristol board.
23	E	8	Direct connected to water wheels.	3	312	14	228	80	80	39.5	A	54	27	235	3,322	120	Straight cut, 6 to inch.	67	.011	News print.
	E	8	do	3	312	14	267	80	80	.....	A	54	27	240	3,396	120	....	67	.011	Do.
	E	4	do	3	312	14	487	80	80	.....	A	54	27	240	3,396	120	....	67	.011	Do.
		1	....	2	560	14	267	80	80	22.00	A	54	27	240	3,396	120	....	67	.011	Do.
24	C	6	....	3	......	....	350	40	....	.....	....	64	26	257	4,310	......	....	....	....	Water fiber, bag, and manila.

25		4		2 or 3		10	200	95	48.5			54	19½							Hanging.
26	L	2	Direct connected to water wheels.				250					52	18							Coating-colored specialties, book.
27	F.B.E.M	23	do.	3		14	300–400	60	60		C	54	25½	215	3,040		Straight cut, 7 to inch.	100	.075	News.
28	M	10	do.	3		16	350–400	32	41.8		C and D.	55	27	200	2,882		Diamond point, 6 to inch.		.075	News and light-weight manilas.
29	J	5	Geared to water wheels.	4			400													Printing, poster, and specialties.
30	L	5	Direct connected to motors.		360	16	400–500	40	52.3	22.40		54	27	204–240	2,885–3,396			90		News, hanging, tablet, novel.
31	A			4		22		35–40	86.5–98.8		B	54	27	190	2,688	120	Straight cut, 8 to inch.	100	.010	Wall.
32	F	4	Direct connected to water wheels.	3		12	450	70	51.6		B	54	27	180	2,545	Hot.	Jig wheels	63	.012	Hanging.
33	L	1		3	384	16	300	45	58.9	23.60		54	27	195	2,760					Manila, building, news, board.
	A	2		3	384	16	300	45	58.9	23.60		54	27	195	2,760					
34	C	4	Direct connected to water wheels.	3		16	250	40	52.3		C	54	27	225	3,182		Diamond point, 8 to inch.			News and manila.
	C	1	Geared to water wheels.	3		16	400	40	52.3											
	C	1	By electric motor.	3		16	500	40	52.3											
35	B		Direct connected to water wheels.	3		12	450	85	62.7		B	54	26	225	3,182	140	Sectional burr	70–75		News and hanging.
36	B	2	do.	3		8	300	110	35.9		D	54	27	154	2,180	Cold.	Diamond point, 6 to inch.		.065 .010	
37	K	2		3		14	440	60	60		A	54	31	220	3,114	150	Sectional burr	70		News.
	K	24		3		14	440	60	60		A	54	27	220	3,114	150	do.	70		
	K	6		3		14	440	60	60		A	49	27	220	2,825	150		70		
	L	2		3		14	440	60	60		A	54	31	220	3,115	150		70		
38	L	2	Geared to water wheels.	3		18	450	70	115.8		A & B.	54	27	200	2,830		Sectional straight cut, 6 and 7 to inch.	80	.075	Hanging.
	L	1	do.	3		18	540	70	115.8		do.	54	27	200	2,830		do.	80	.075	
39	E	3		3	225	12	500	40	29.4	20.14		54	27	200	2,830					Bag and manila.
40	M	2		3		14	480	50	50		B	48	27	165	2,078		Diamond point.	80		
41	B	12	Direct connected to water wheels.	3		16	280	60	78.4		B & E.	54	28	250	3,540	112	Diamond point, 7 to inch.	62	.012	News, colored fiber, book.
	L	3	do.	3		16	600	60	78.4		do.	54	28	250	3,540	112		62	.012	Do.
42	I	1					456					42		224	2,465			100		
	N	2					456					42		120	1,320			100		
43		2		2	256	14	150	35	35	21.05		52	13	115	1,569					Covers, colored flats, specialties.

[1] Round perforations.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—**Continued.**

Number of mill.	Make of grinder.	Number of grinders.	How driven.	Number of pockets.	Pocket area.	Diameter of cylinders.	Approximate horse-power to grinder.	Pressure on cylinders.	Equivalent pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Stone.					Temperature of grinding.	Kind of burr.	Approximate horse-power per ton.	Size of screen slots or perforations.	Kind of paper produced.
											Kind.	Diameter.	Width of face.	Revolutions per minute.	Peripheral speed.					
					Sq. in.	*In.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs.*		*In.*	*In.*		*Ft. per min.*	*° F.*			*In.*	
44	O	1		3	300	16		50	65.3	33.50	B	54	20	195	2,760		Sectional cut, 8 to inch.	105		Tissue and light-weight manila.
	L	1		3	300	16		50	65.3	33.50	B	54	20	195	2,760			105		
	P	1		3	300	16		50	65.3	33.50	B	54	20	195	2,760			105		
45	L	4		3	336	14	250	60	60	27.50		54	27	120	1,699					
46	M			2		14		40	40		D	54	27	225	3,182	Hot.	Diamond point, 6 to inch.	55	0.085	Heavy board.
47	E	4		3	252	10	325	75	38.3	23.40		50	20	220	2,880					Boards, and milk-bottle cap stock.
48	D	8	Geared to water wheels.	3		12	275	38	27.9		B	54	27	200	2,830	Hot.	Diamond point.	75	.012 / .075	
49	D	2	Direct connected to water wheels.	3		10	150	80	40.9		B	52	27	160	2,180	145	Diamond point, 10 to inch.	90		
	D	3	Geared to water wheels.	3		10	300				B	52	27	160	2,180	145	do.	90		
50	L	5	Direct connected to water wheels.	3		16	475	35	45.7		B	54	27	180	2,545	160	Washers.	90	.012	Do not make paper.
51	B	15	Geared to water wheels.	2		9		19			B	52	26½	190	2,690	130	Diamond point, 7 to inch.	70		
	J	4	do.																	
52	L	4		3	416	16	410	40	52.2	19.32		54	27	225	3,182					
53	L	4	Direct connected to water wheels.				410					54	27	200	2,830					Wrapping manilas, tissue, specialties.
54		2				16		35	45.7			52					Straight cut.			Manila.
55	B	6		3	196	12	350					54	26							News, manila, poster.
	L	6		3	336	14	500					54	27							
	L	6		3	336	14	285					54	27							
56	L	16	Direct connected to water wheels.	3			283				D	54		215	3,040					
57	B	3	do.	2		12	333	100	73.5		B	54	24							
58	E	2		3	336	12	300	35	25.7	11.8		54	27	175	2,478					Manila and tissue.

	B	2		3		12	300	35	25.7			54	27	175	2,478					
59	F	8	Direct connected to water wheels.	3		12	250	40	29.4		Domestic and foreign.	54	27	200	2,830	150	Sectional cut, 5 to inch.	80	.055	Pulp for news, card, manila.
60*a*	L	12	do	3		14	350	45	45		A and B.	54	27	180	2,545	150	Diamond point cut, 8 to inch.	95	.014 .013	News.
60*b*	L	5	do	3		16	500	40	52.2		A	54	32	200	2,830	177	do			News, manila, fiber.
61	A	1	do	3		16		35	45.7		A	45	27	200	2,360	Hot.	Straight cut, 8 to inch.	125	.065	Bag and colored specialties.
62	B		Direct connected to motor.	2		14	375	90	90		D	51	30	240	3,204		Straight cut, 6 to inch.	83		
63	L	10	Direct connected to water wheels.	3		16	500	35	45.7					200	2,830					
	L	3	do	3		16	400	35	45.7		C	54	28	200	2,830	185		85	.012	News and manila.
	D	3	Geared to water wheels.	3		16	400	35	45.7					200	2,830					
64	Q	6	Direct connected to water wheels.	3		12	275	59	43.4		B	26	26			125		75		News.
	E	2	do	3		12	275	59	43.4		B		26			125		75		
65	C	5	Geared to water wheels.	3		10½	250	60	33.6		C	54	27	160	2,262	130	Diamond point, 7 to inch.	80	.065	News and board.
66	B	6	Direct connected to water wheels.	2		14	150	75	75		B	52	27	100	1,362	100	Spiral and pick, 7 to inch.	100	.010	No. 3 book.
67	A			3		16		25	32.6		A	54	27	200	2,830	138	Straight cut, 6 to inch.	80	.010	News.
68	R	9		2							B	48	20	125	1,572	Cold.	do			Book and news.
69	F	28	Direct connected to water wheels.	3			450	82				54	27	200	2,830					News, cover, wrapping.
70	F			3		10		90	45.9		A	54	26	200	2,830	110	Straight cut, 6 to inch.	75	.011	News.
71	S	2	Direct connected to water wheels.	3		8	400–260	60	19.6		B	52	26	200	2,724	Hot.	do	100	.012	Tissue.
72	M	4	do	3		12		80	58		B	54	18	200	2,830	145	Straight cut, 5 and 6 to inch.	60	.075	Hanging, bag, news.
73	M	2			432		350	40				54	27							Manila, bag.
	A	7			432		350	40				54	27							
74	K	2	Direct connected to water wheels.	3		14	350	100	100		B	54	27	135	1,910	150	Diamond point, 8 to inch.		.014	Tag, bristol, box board, cover, wrapping.
	K	2	Geared to water wheels.	3		12	300	100	73.9		B	54	27	135	1,910	150	do		.014	
75	A	10	Direct connected to water wheels.	3	336	16	350	38	49.6	22.75	D	54	26	200	2,830	130	Straight cut, 8 to inch.	60	.075	News and hanging.
	A	4	Motor driven	3	336	16	250	38	49.6	22.75	D	54	26	200	2,830	130	do	60	.075	
76	C	10		3		14	350	60	60			48	26	160	2,012					News.
77	F	2		3	304	10	250	100	51	25.80		50	20	250	3,275					
	E	2		3	304	16	250	60	78.4	39.80		52	20	250	3,415					
78	K	5	Geared to water wheels.	3		16		40	52.3		D	54	27	225	3,182	Hot.	Straight cut, 6 to inch.	80	.011	Extra news.

TABLE 2.—*Commercial conditions in the manufacture of ground wood pulp*—Continued.

Number of mill.	Make of grinder.	Number of grinders.	How driven.	Number of pockets.	Pocket area.	Diameter of cylinders.	Approximate horse-power to grinder.	Pressure on cylinders.	Equivalent pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Stone. Kind.	Stone. Diameter.	Stone. Width of face.	Stone. Revolutions per minute.	Stone. Peripheral speed.	Temperature of grinding.	Kind of burr.	Approximate horse-power per ton.	Size of screen slots or perforations.	Kind of paper produced.
					Sq. in.	*In.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs.*		*In.*	*In.*		*Ft. per min.*	*° F.*			*In.*	
79	T	6	Direct connected to water wheels.	3		14	300	45	45		B	54	26	185	2,620	85	Six cut, sectional.	70		News and hanging.
80	A			3		16		80	104.5		A	54	27	230	3,255	70	Straight cut, 6 to inch.	50	0.010	News.
81		7		3	192	10	375	85	43.4	34.80		54	20	230	3,255					
82	L	4	Direct connected to water wheels.	3		12	430	40	29.6		B	54	18	240	3,396	120				News and hanging.
	O	2	do	3		12	525	40	29.6		B	54	18	240	3,396	120				
83				4		12		35	25.8		D	52	28			110		70	.009	News.
84	F	4	Direct connected to water wheels.	3		12	420	70	51.6		D	54	27	180	2,545	Above 60.	Jig wheels	63	.012	Hanging.
85	P	3	Direct connected to water wheels	3		14	321	80	80		D	54	27	200	2,830	110	Straight cut, 5 to inch.	67	.012	Pie plates, box board, news, book, wrapping.
	B	2	Belted to water wheels.				250													
86	M	4	Direct connected to water wheels.	3		12	400	40	29.6		D	54	27	185	2,620	108	Straight cut, 4 to inch.	64		Manila, tissue.
87	C	8	Geared to water wheels.	2		12	150	40	29.6		B	50	20	220	2,880	120	Diamond point, 6 to inch.	70	.014	News, poster, linings.
88	U			2				25			B	48	24	250	3,140			65	.016	Tissue and special wrapping.
89	B			3		14		55	55		A	54	26	140	1,980	(1)	Diamond point, 6 to inch.	100	.065	Book.
90a	A	3	Geared to water wheels.	3		16	545				B	54	27	170	2,404	80	Spiral cut, 6 to inch.	90	.014	News, bag, manila, wall.
90b	L	4	do	3		16	297	20	26.2		B	54	27	170	2,404	80	do	90	.014	Do.
90c	L	7	do	3		16	297	20	26.2		B	54	27	170	2,404	80	do	90	.014	Do.
	A	1	do	3		16	297	20	26.2		B	54	27	170	2,404	80	do	90	.014	Do.
90d	L	7	do	3		16	255	20	26.2		B		20	170	2,404	80	do	90	.014	Do.

91	D	3	Direct connected to water wheels.	2		11½		60			B	54	27	186	2,632	149	Straight cut, 6 to inch.	67	.012	Wrapping.
	C	2	do																	
92	D	8	do	3		10	225	110	56.1		C	54	27	240	3,396	90	Diamond point, 8 to inch.	75	.060	Tag, and box board.
93	A			4		16		45	58.9		B	55	27	185	2,420	120	Diamond point, 7 to inch.		.070	
94	D	6	Geared to water wheels.																	Fiber and manila.
95	E	7	Direct connected to water wheels.	3		16	350	37	48.4		B	54	26	180	2,545	115	Straight cut	70	.010	News.
	E	1	Electric power	3		16	350				B	54	26	180	2,545	115	do	70	.010	Do.
96	B	1	Geared to water wheels.				350	35	40.1											Hanging and news.
	B	6	do				450	35	40.1											
	F	1	do	3		15	500	35	40.1		D	54	27	250	3,540	140	Straight cut, sectional, 5 to inch.	90	.089	News.
	B	3	Direct connected to water wheels.				350	35	40.1											
	C	4	do	3		15	375	35	40.1											
97	D			3		7	300	95	23.8		C	50	27							Manila wrapping.
98	F		Direct connected to water wheels.	3		12	275	75–80	55.4–59		B	52	27	180	2,455	90	Straight cut, 4 to inch.	50	.015	Colored fiber and express.
99	K			3		16		42	54.9		B	48	27	230	2,892	155	Sectional cut, 6 to inch.	65		News.
100	L	2		3		16	300	40	52.3		B	54	27	215	3,042		do			
101	L	6	Direct connected to water wheels.	3		16	350	16	20.9		B	52	26	135	1,840	140	5 threads to inch.	70		Bag and manila wrapping.
102	F			3		12		60	44.3		B	52	27	180	2,454	212	Diamond point, 9 to inch.	80		Print paper and manilas.
103	V			6			1,500	[2]			D	52	18	195	2,660	110	Hand picked			
104	K	16		3	434	16	625	55	71.9			54	30	250	3,540					News.
105		3		3	224	16		50	65.3			54	28	200	2,830					Do.
106	A	10		4		16	405	25–30	32.6–38.2			54	27	200	2,830					News, manila, bag, tissue, wrapping, sheathing, and hanging.
	A	6		4		16	405	40	52.3			54	27	210	2,970					
	A	3		4		16	500	35–40	45.7–52.3			54	27	240	3,396					
	F	2		3		10	353	65	33.2			54	27	250	3,540					
	A	4		4			400					54	26	200	2,830					
107	M	1		3	312	14	300	35	35			54	28	250	3,540					Tissue.
108	F	57		3		12	350	60	44			54	27	200–225	2,830 3,182					News.

[1] Ordinary.

[2] Mechanical feed.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated.*

Wood shipment No.	Run number.	Kind of burr.	Surface of stone.	Pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Revolutions per minute.	Peripheral speed.	Average horsepower to grinder.	Maximum horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Solid rossed wood ground in 24 hours.	Weight per cubic foot bone-dry wood.	Average diameter of wood.	Moisture in wood.	Bone-dry pulp per 100 cubic feet solid rossed wood.	Efficiency of conversion.	Screenings per 100 cubic feet solid rossed wood bone-dry.	Stock in white water per 100 cubic feet solid rossed wood bone-dry.	Average temperature of grinding.	Horsepower ÷ pressure × speed.
				Lbs. per sq. in.	*Lbs.*		*Ft. per min.*			*Tons.*		*Cu. ft.*	*Lbs.*	*In.*	*P. ct.*	*Lbs.*	*P. ct.*	*Lbs.*	*Lbs.*	*° F.*	
W-10[1]	[2]1	Straight cut, 3 to inch; spiral cut, 12 to inch.	Freshly dressed	40,50	16.4 20.5	175	2,445	403	....	4.988	80.8	......	......	....	......	......	....	......	......	171	......
W-10[1]	[2]1	do	Same, not re-dressed.	40,50	16.4 20.5	175	2,445	399	....	4.525	88.1	......	......	....	......	......	....	......	......	175.5	......
Weighted averages.	......	......	......	40,50	16.4 20.5	175	2,445	401	....	4.810	83.5	386.2	28.4	....	28.90	2,480	87.4	17.2	......	172.6	......
W-9[1]	[2]2	Straight cut, 3 to inch; Spiral cut, 12 to inch.	Freshly dressed	40	16.4	200	2,795	398	....	4.245	93.8	......	......	....	......	......	....	......	......	164.3	0.00991
W-9[1]	[2]2	do	Same, not re-dressed.	40	16.4	200	2,795	408	....	3.995	102.0	......	......	....	......	......	....	......	......	171.3	.01017
W-9[1]	[2]2	do	do	40	16.4	200	2,795	394	....	4.175	94.4	......	......	....	......	......	....	......	......	166.7	.00981
Weighted averages.	......	......	......	40	16.4	200	2,795	402	....	4.120	97.5	409.5	22.72	....	39.33	2,012	88.5	13.75	......	168.0	.01002
W-10[1]	3	Straight cut, 3 to inch; spiral cut, 12 to inch.	Freshly dressed	20	8.2	175	2,445	191	215	1.215	157.0	105.4	27.66	....	30.14	2,300	83.2	9.82	......	163.0	.00954
W-10[1]	4	do	Same, not re-dressed.	40	16.4	175	2,445	333	388	3.025	110.0	251.3	27.66	....	30.14	2,408	87.1	17.80	......	166.5	.00830
W-10[1]	5	do	do	60	24.65	175	2,445	454	506	5.255	86.4	436	27.66	....	30.14	2,415	87.3	18.60	......	152.2	.00753
W-10[1]	6	do	do	20	8.2	225	3,145	225	264	1.198	188.0	106.2	27.66	....	30.14	2,255	81.5	9.66	......	179.8	.00873
W-10[1]	7	do	do	40	16.4	225	3,145	412	494	3.775	109.0	314	27.66	....	30.14	2,404	87.0	10.15	......	163.8	.00799
W-10[1]	8	do	do	60	24.65	225	3,145	567	651	6.215	91.2	474.5	27.66	....	30.14	2,624	95.0	15.70	......	158.3	.00731
W-10[1]	9	Spiral cut, 6 to inch.	Freshly dressed	20	8.2	175	2,442	174.7	222	.995	175.5	93.7	27.66	....	30.14	2,122	76.8	13.54	......	165.5	.008715
W-10[1]	9-1	do	Same as for No. 14.	20	8.2	175	2,442	178.5	212	1.910	93.5	166.4	27.52	....	29.29	2,295	83.5	12.60	......	144.2	.00891
W-10[1]	10	do	Freshly dressed	40	16.4	175	2,442	287	357	3.850	74.5	311.0	27.66	....	30.14	2,478	89.5	21.10	......	139.2	.007155
W-10[1]	11	do	Same, not re-dressed.	60	24.65	175	2,442	397	480	6.060	65.5	505	27.66	....	30.14	2,400	86.8	56.5	......	142.2	.00659
W-10[1]	12	do	do	20	8.2	225	3,140	225	280	2.995	75.2	216.6	27.66	....	30.14	2,302	83.3	19.57	......	154.0	.00874

W-10 [1]	13	do	do	40	16.4	225	3,140	356	431	5.305	67.2	431	27.90	....	29.90	2,464	88.7	16.75	......	137.0	.00691
W-10 [1]	14	do	do	60	24.65	225	3,140	508	586	7.840	64.9	654	28.11	....	29.04	2,400	85.4	30.95	......	135.7	.00656
W-10 [1]	15	Diamond point, 8 to inch.	Freshly dressed	20	8.2	175	2,442	183	210	1.435	127.6	120.3	27.52	....	29.29	2,390	81.9	11.05	......	163	.00913
W-10 [1]	16	do	Same, not re-dressed.	40	16.4	175	2,442	327	388	3.705	88.2	326	27.59	....	27.81	2,272	82.4	13.20	......	147	.00815
W-10 [1]	17	do	do	60	24.65	175	2,442	426	489	5.340	79.8	455	27.59	$6\frac{1}{8}$	27.81	2,345	85.0	9.84	......	141	.00707
W-10 [1]	18	do	do	20	8.2	225	3,140	234	287	2.088	112.0	181	27.59	$5\frac{3}{4}$	27.81	2,307	83.7	7.75	......	158.2	.00909
W-10 [1]	19	do	do	40	16.4	225	3,140	379	441	4.220	89.8	359	27.59	6	27.81	2,350	85.2	12.60	......	151.8	.00735
W-10 [1]	20	do	do	60	24.65	225	3,140	521	592	6.360	82.0	534.5	29.12	$5\frac{1}{8}$	27.32	2,380	81.8	11.50	......	148.6	.006735
W-10 [1]	21	Straight cut, 3 to inch; spiral cut, 12 to inch.	Freshly dressed	40	16.4	175	2,442	312	378	2.155	144.8	200	27.80	$3\frac{5}{8}$	27.42	2,155	77.5	7.45	......	170.8	.00778
W-10 [1]	22	do	Same, not re-dressed.	40	16.4	175	2,442	321	365	2.260	142	197.5	28.34	$8\frac{3}{4}$	27.57	2,290	80.8	7.73	......	171.5	.00800
W-9 [1]	23	do	do	40	16.4	175	2,442	324	372	2.415	134	267.5	21.08	14	37.74	1,820	86.3	7.84	......	163.1	.008085
W-10 [1]	24	do	Freshly dressed	60	24.65	100	1,398	299	359	3.005	99.5	255	27.60	$5\frac{3}{4}$	31.70	2,360	85.5	12.90	......	140.2	.00867
W-10 [1]	25	do	Same, not re-dressed.	60	24.65	150	2,093	416	478	4.655	89.4	382	29.05	$5\frac{5}{8}$	27.90	2,440	84.0	20.00	......	149.5	.00807
W-10 [1]	26	do	do	60	24.65	200	2,792	529	605	5.960	88.7	481.6	29.05	$5\frac{5}{8}$	27.90	2,476	85.1	20.06	......	149.3	.00768
W-10 [1]	27	do	do	60	24.65	250	3,490	640	731	7.850	81.5	675	27.02	5	28.40	2,326	86.0	11.00	......	138.6	.00743
W-10 [1]	28	do	do	30	12.3	250	3,490	350	397	2.938	119.2	251.5	28.68	$5\frac{5}{8}$	30.40	2,340	81.5	8.54	......	163.2	.00811
W-10 [1]	29	do	do	40	16.4	188	2,624	355	428	2.950	120.3	247	28.68	$5\frac{3}{4}$	30.40	2,390	83.3	11.20	......	171.3	.00824
W-10 [1]	29-1	do	Same as for No. 31.	40	16.4	188	2,624	343	407	2.685	127.7	236.2	27.24	$5\frac{5}{8}$	28.30	2,275	83.5	10.27	......	172.8	.00796
W-10 [1]	30	do	Same as for No. 29.	50	20.5	150	2,093	356	391	3.850	92.5	318	26.88	$5\frac{5}{8}$	31.00	2,420	90.0	9.94	......	146.3	.00830
W-10 [1]	31	do	Same, not re-dressed.	60	24.65	125	1,745	358	398	3.580	100.0	306	26.88	$5\frac{7}{8}$	31.00	2,340	87.0	15.00	......	151.0	.008315
W-10 [1]	32	do	Freshly dressed	30	12.3	250	3,470	314	385	5.200	60.4	441.5	27.24	$5\frac{3}{8}$	28.30	2,355	86.6	13.20	......	124.4	.00736
W-10 [1]	33	do	Same, not re-dressed.	35	14.36	214	2,970	344	404	6.040	57.0	505	27.24	$5\frac{7}{8}$	28.30	2,390	87.8	12.05	......	131.5	.00806
W-10 [1]	34	do	do	40	16.4	188	2,609	320.5	389	5.290	60.6	452	27.24	$5\frac{1}{8}$	28.30	2,338	85.8	14.18	......	123.2	.00749
W-10 [1]	35	do	do	45	18.46	167	2,318	341	392	5.255	64.9	444	27.35	$5\frac{1}{2}$	29.98	2,370	86.6	10.48	......	128.0	.007975
W-10 [1]	36	do	Same as for No. 35.	50	20.5	150	2,081	339	399	5.230	64.8	445	27.35	$5\frac{1}{2}$	29.98	2,355	86.1	13.22	......	127.4	.00795
W-10 [1]	37	do	Same, not re-dressed.	55	22.6	136	1,887	328	381	5.200	63.1	432	27.35	$5\frac{3}{4}$	29.98	2,410	88.1	18.96	......	129.5	.00770
W-10 [1]	38	do	do	60	24.65	125	1,734	327	380	4.870	67.1	428	27.35	$5\frac{7}{8}$	29.98	2,280	83.4	21.80	......	131.7	.00765
W-10 [1]	39	do	Freshly dressed	50	20.5	200	2,775	429	495	5.875	73.0	502	27.60	$5\frac{1}{2}$	31.40	2,340	84.8	13.20	......	86.0	.00754
W-10 [1]	40	do	Same, not re-dressed.	50	20.5	200	2,775	400.5	481	5.240	76.5	434	27.60	$5\frac{1}{2}$	31.40	2,418	87.6	13.13	......	116.6	.00704
W-10 [1]	41	do	do	50	20.5	200	2,775	453	515	6.210	72.9	529	27.60	$5\frac{1}{8}$	31.40	2,350	85.2	17.92	......	159.3	.00797
W-10 [1]	42	do	do	20	8.2	175	2,428	164	183	1.640	101.2	132	28.35	$5\frac{5}{8}$	33.25	2,455	86.5	6.83	......	85.0	.00824
W-10 [1]	43	do	do	40	16.4	175	2,428	315.5	366	3.110	101.3	252	28.35	5	33.25	2,470	87.0	7.98	......	87.8	.00792
W-10 [1]	44	do	do	60	24.65	175	2,428	442	526	5.145	86.0	392	28.35	6	33.25	2,620	92.4	13.12	......	86.7	.00739
W-10 [1]	45	do	do	20	8.2	175	2,428	177.7	209	1.105	116.7	89.1	28.35	$5\frac{7}{8}$	33.25	2,480	87.5	11.90	......	176.3	.00892
W-9 [1]	46	do	do	40	16.4	175	2,428	323	360	3.410	94.7	350	22.40	$6\frac{1}{4}$	44.00	1,950	87.0	9.50	......	152.7	.00778
W-9 [1]	47	do	do	60	24.65	175	2,428	449	531	5.610	79.9	582	22.40	$6\frac{1}{2}$	44.00	1,930	86.1	15.83	......	145.0	.00719
W-9 [1]	48	do	do	20	8.2	175	2,428	176.8	222	1.350	131.0	144.6	22.40	$6\frac{3}{8}$	44.00	1,870	83.5	3.48	......	86.4	.00888
W-9 [1]	49	do	do	40	16.4	175	2,428	320	406	2.820	113.5	289	22.40	6	44.00	1,952	87.2	8.45	......	86	.00803
W-9 [1]	50	do	do	60	24.65	175	2,428	435	487	4.680	93.0	461	22.40	$6\frac{1}{2}$	44.00	2,030	90.6	9.22	......	89.3	.00726
W-17 [1]	[3] 52	do	Freshly dressed	20	8.2	225	3,107	148	160	.816	181.2	80	26.61	$5\frac{5}{8}$	24.14	2,040	76.6	6.65	......	171.3	.00581

[1] Seasoned.

[2] Commercial.

[3] Wood was ground in two pockets at a time.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated*—Continued.

Wood shipment No.	Run number.	Kind of burr.	Surface of stone.	Pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Revolutions per minute.	Peripheral speed.	Average horsepower to grinder.	Maximum horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Solid rossed wood ground in 24 hours.	Weight per cubic foot bone-dry wood.	Average diameter of wood.	Moisture in wood.	Bone-dry pulp per 100 cubic feet solid rossed wood.	Efficiency of conversion.	Screenings per 100 cubic feet solid rossed wood bone-dry.	Stock in white water per 100 cubic feet solid rossed wood bone-dry.	Average temperature of grinding.	Horsepower ÷ pressure × speed.
				Lbs. per sq. in.	*Lbs.*		*Ft. per min.*			*Tons.*		*Cu. ft.*	*Lbs.*	*In.*	*P. ct.*	*Lbs.*	*P. ct.*	*Lbs.*	*Lbs.*	*° F.*	
W-17 [1].....	[4] 53	Straight cut, 3 to inch; spiral cut, 12 to inch.	Same, not redressed.	40	16.4	225	3,107	282	334	2.695	104.7	249	26.61	6¾	24.14	2,160	81.1	9.70	......	159.3	0.00553
W-17 [1].....	[4] 54	.....do..	.....do............	60	24.65	225	3,107	394	447	5.770	68.3	519	26.34	4⅝	25.12	2,225	84.5	11.40	......	137.8	.00514
W-17 [1].....	[4] 55	.....do..	.....do............	80	32.8	225	3,107	497	551	8.340	59.6	738	26.34	4⅝	25.12	2,258	85.7	15.85	......	136.3	.00487
W-17 [1].....	[4] 56	.....do..	.....do............	100	41.0	225	3,107	556	621	9.770	57.0	860	26.34	5⅝	25.12	2,272	86.2	20.24	......	133.7	.00436
W-17 [1].....	[4] 58	.....do....	Freshly dressed...	40	16.4	250	3,452	285	326	4.600	62.0	403	26.34	6¼	25.12	2,280	86.6	7.35	......	139.1	.00504
W-17 [1].....	[4] 59	.....do..	Same, not redressed.	60	24.65	250	3,452	426	460	......	......	......	......	....	......	......	.....	......	......	......	.00500
W-17 [1].....	60	.....do..	Freshly dressed...	40	16.4	100	1,381	194	242	2.110	92.0	190	27.11	5	25.31	2,220	81.9	9.43	......	141.5	.00856
W-17 [1].....	61	.....do..	Same, not redressed.	40	16.4	150	2,071	275	318	3.005	91.5	271	25.03	4¾	30.54	2,218	88.5	11.16	......	146.8	.00810
W-17 [1].....	62	.....do..	.....do............	40	16.4	200	2,762	354	427	4.080	86.7	358	25.03	5½	30.54	2,280	91.0	8.50	......	143.9	.00781
W-17 [1].....	63	.....do..	.....do............	40	16.4	250	3,452	407	460	4.980	81.8	439	25.03	5¼	30.54	2,270	90.6	7.91	......	144.1	.00720
W-17 [1].....	64	.....do..	.....do............	60	24.65	100	1,381	275	322	3.500	78.6	303	25.72	5⅛	28.83	2,310	89.9	18.27	......	141.1	.00806
W-17 [1].....	65	.....do..	.....do............	60	24.65	150	2,071	362	419	4.500	80.5	398	25.72	5½	28.83	2,262	88.0	11.82	......	137.7	.00709
W-17 [1].....	66	.....do..	.....do............	60	24.65	200	2,762	481	560	5.800	83.0	505	25.72	5⅝	28.83	2,298	89.3	12.32	......	143.0	.00706
W-17 [1].....	67	.....do..	.....do............	60	24.65	250	3,452	546	620	7.335	74.5	675	25.08	5⅛	27.64	2,170	86.5	13.53	......	140.0	.00641
W-17 [1].....	[4] 68	.....do..	.....do............	40	16.4	250	3,452	304	350	3.715	81.8	336	25.88	6⅛	27.34	2,210	85.4	7.22	......	144.8	.00536
W-17 [1].....	[4] 69	.....do..	.....do............	60	24.65	250	3,452	401	431	5.590	71.8	489	25.88	5⅜	27.34	2,280	88.1	10.22	......	138.8	.00471
W-17 [1].....	[4] 70	.....do..	.....do............	80	32.8	250	3,452	510	564	8.100	63.0	709	25.94	5⅛	28.40	2,285	88.1	13.28	......	134.6	.00450
W-18 [1].....	[4] 71	.....do..	.....do............	100	41.0	250	3,452	543	661	8.930	60.8	780	26.15	6	32.38	2,288	87.5	11.26	......	129.2	.00384
W-18 [2].....	[3] 74	.....do..	Same as for No. 73 [3].	60	24.65	175	2,417	451.5	502	5.025	89.9	492	27.09	6¼	39.70	2,042	75.5	9.90	......	145.4	.00760
W-18 [2].....	75	.....do..	Same, not redressed.	40	16.4	175	2,417	330	367	2.900	113.8	275	27.09	7	39.70	2,110	77.9	7.60	......	149.2	.00833
W-18 [2].....	76	.....do..	.....do............	20	8.2	175	2,417	185.7	239	.987	188.0	98.5	27.09	6¾	39.70	2,004	74.1	5.67	......	174.1	.00938
W-18 [1].....	80	.....do..	Same as for No. 79 [3].	20	8.2	175	2,417	183	239	.640	286	63.5	27.47	5⅝	28.33	2,016	74.3	10.43	......	181.8	.00925
W-18 [1].....	81	.....do..	Same, not redressed.	40	16.4	175	2,417	334	392	2.525	132.2	237	27.47	5⅝	28.33	2,125	77.4	10.40	......	161.2	.00843
W-18 [1].....	82	.....do..	.....do............	60	24.65	175	2,417	449	527	4.590	97.8	413	27.47	5⅝	28.33	2,220	80.8	15.07	......	148.0	.00754
W-18 [2].....	83	.....do..	Same as for No. 82.	60	24.65	100	1,381	281	323	2.850	98.6	269	27.09	7¼	39.70	2,120	78.2	15.05	......	148.1	.00824

W-18[2]	84	do	Same, not re-dressed.	60	24.65	150	2,072	414	467	3.530	117.2	309	27.12	6¼	37.56	2,284	84.4	20.50	......	155.8	.00810
W-18[2]	85	do	do	60	24.65	200	2,762	495	550	5.350	92.6	481	27.12	6½	37.56	2,220	81.9	14.21	......	148.7	.00726
W-18[2]	86	do	do	60	24.65	250	3,452	608	677	6.875	88.4	686	26.38	8	40.15	2,004	76.1	10.40	......	143.6	.00714
W-18[2]	[4] 87	do	do	40	16.4	250	3,452	315	358	2.600	121.1	260	26.38	7½	40.15	2,000	75.9	6.14	......	161	.00556
W-18[2]	[4] 88	do	do	60	24.65	250	3,452	439	485	3.840	114.2	405	25.15	7¾	41.24	1,893	75.4	10.46	......	169	.00515
W-18[2]	[4] 89	do	do	80	32.8	250	3,452	560	609	6.520	85.9	675	25.15	6½	41.24	1,932	77.0	13.18	......	147.6	.00495
W-18[2]	[4] 90	do	do	100	41.0	250	3,452	640	699	8.140	78.6	823	25.15	6¼	41.24	1,978	78.7	13.59	......	150.3	.00452
W-18[2]	91	do	do	54	22.15	250	3,452	554	610	4.755	116.4	482	25.15	6½	41.24	1,972	78.5	9.25	......	161.1	.00725
W-18[1]	92	Diamond point, cut 6 to the inch.	Freshly dressed	100	41.0	250	3,452	650	723	......	......	......	27.51	6½	27.47	......	......	......	......	126.5	.00460
W-18[1]	93	Diamond point, cut 6 to inch.	Same, not re-dressed.	20	8.2	250	3,452	276.5	286	......	......	......	27.51	6½	27.47	......	......	......	......	136.0	.00906
W-18[1]	94	Spiral cut, 6 to inch.	Freshly dressed	100	41.0	250	3,435	572.5	653	......	......	......	27.51	5⅜	27.47	......	......	......	......	107.6	.00407
W-18[1]	95	do	Same, not re-dressed.	20	8.2	250	3,435	232.5	278	......	......	......	27.51	5⅜	27.47	......	......	......	......	110.6	.00826
W-18[1]	96	Straight cut, 3 to inch; spiral cut, 12 to inch.	Freshly dressed	40	16.4	200	2,748	310	390	......	......	......	27.51	5⅜	27.47	......	......	......	......	113.6	.00687
W-18[1]	112	do	Same as for No. 111.[5]	40	16.4	200	2,748	326	392	4.320	75.5	380	27.00	5⅝	29.84	2,270	84.3	8.41	......	141.8	.00723
W-18[2]	114	do	Same as for No. 113.[5]	40	16.4	200	2,748	342	388	4.625	73.9	405	27.19	6	39.66	2,282	84.1	7.96	......	110.9	.00758
W-18[2]	[6] 120	do	Same as for No. 119.[5]	120	49.2	225	3,092	307	370	5.260	58.3	513	25.05	5⅞	40.34	2,055	82.0	13.42	158.4	124.5	.00202
W-18[2]	[4] 121	do	Same, not re-dressed.	59.5	24.4	225	3,092	347	392	5.280	65.7	496	25.05	6	40.34	2,130	85.0	8.44	......	128.1	.00460
W-18[2]	122	do	do	36.5	14.98	225	3,092	335	411	3.770	88.9	360	25.05	6	40.34	2,093	83.5	5.22	305.0	149.5	.00724
W-18[2]	123	do	do	60	24.65	225	3,092	493	556	5.665	87.0	629	24.84	6¼	43.02	1,805	72.6	6.95	......	133.7	.00646
W-18[2]	124	do	Freshly dressed	60	24.65	225	3,085	595	665	7.485	79.5	790	24.84	6½	43.02	1,898	76.3	10.40	......	137.8	.00781
W-18[2]	125	do	Same, not dressed.	40	16.4	225	3,085	419	475	4.390	95.5	426	24.84	6	43.02	2,058	82.7	6.79	134.0	141.3	.00826
W-18[2]	126	do	do	20	8.2	225	3,085	232	290	1.703	136.2	176	24.84	6¾	43.02	1,928	77.5	5.37	......	163.8	.00916
W-20[1]	127	do	do	60	24.65	225	3,085	567	629	6.950	81.6	577	28.01	5⅜	29.09	2,405	85.9	15.90	......	145.0	.00745
W-20[1]	128	do	do	40	16.4	225	3,085	417	469	4.490	93.0	374	28.01	5	29.09	2,402	85.8	13.53	......	153.8	.00825
W-20[1]	129	do	do	20	8.2	225	3,085	231	264	1.517	152.2	129	28.01	5¼	29.09	2,350	83.9	11.89	......	167.0	.00913
W-20[1]	133	do	Same as for No. 132.[5]	40	16.4	225	3,085	413	496	4.750	87.0	402	27.66	4⅝	28.08	2,360	85.4	8.39	......	133.2	.00816
W-20[1]	134	do	Same, not re-dressed.	40	16.4	225	3,085	411	478	4.210	97.8	353	27.66	5	28.08	2,380	86.0	13.34	......	172.0	.00813
W-20[1]	[4] 135	do	do	60	24.65	225	3,085	403	470	5.765	69.9	469	27.96	4⅝	26.41	2,460	88.0	10.70	......	121.4	.00530
W-20[1]	[4] 136	do	do	60	24.65	225	3,085	416	472	5.785	72.0	475	27.96	5⅛	26.41	2,435	87.0	13.75	116.0	173.0	.00547

[1] Seasoned.
[2] Green.
[3] The low values of yield secured in runs Nos. 74 to 124 are the result of operating with a sulphite felt on the wet machine.
[4] Wood was ground in two pockets at a time.
[5] See Table 4.
[6] Wood was ground in one pocket at a time.

TABLE 3.—*Grinder runs on green and seasoned spruce, untreated*—Continued.

Wood shipment No.	Run number.	Kind of burr.	Surface of stone.	Pressure on 14-inch cylinder.	Pressure per square inch of pocket area.	Revolutions per minute.	Peripheral speed.	Average horsepower to grinder.	Maximum horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Solid rossed wood ground in 24 hours.	Weight per cubic foot bone-dry wood.	Average diameter of wood.	Moisture in wood.	Bone-dry pulp per 100 cubic feet solid rossed wood.	Efficiency of conversion.	Screenings per 100 cubic feet solid rossed wood bone-dry.	Stock in white water per 100 cubic feet solid rossed wood bone-dry.	Average temperature of grinding.	Horsepower ÷ pressure × speed.
				Lbs. per sq. in.	*Lbs.*		*Ft. per min.*			*Tons.*		*Cu. ft.*	*Lbs.*	*In.*	*P. ct.*	*Lbs.*	*P. ct.*	*Lbs.*	*Lbs.*	*° F.*	
W-20[1]......	137	Straight cut, 3 to inch; spiral cut, 12 to inch.	Same, not redressed.	20	8.2	175	2,400	188	215	1.465	128.3	119.6	28.04	5½	27.75	2,450	87.4	10.30	......	148.3	0.00955
W-20[1]......	138	.....do...........	.....do.............	40	16.4	175	2,400	338	384	3.435	98.5	278	28.04	5½	27.75	2,470	88.0	9.45	182.0	150.1	.00859
W-20[1]......	139	.....do...........	.....do.............	60	24.65	175	2,400	462	515	5.805	79.6	466	28.04	5¼	27.75	2,490	88.7	10.97	113.0	146.0	.00780
W-20[1]......	140	.....do...........	.....do.............	20	8.2	175	2,400	180	225	1.419	127.0	115.8	28.04	5½	27.75	2,450	87.4	10.70	157.0	159.3	.00915
W-20[1]......	141	.....do...........	.....do.............	40	16.4	175	2,400	323	346	3.495	92.5	282	28.04	6	27.75	2,480	88.4	12.11	125.0	152.9	.00821
W-20[1]......	142	.....do...........	.....do.............	60	24.65	175	2,400	465	515	5,775	80.5	475	28.04	5⅜	27.75	2,435	86.7	14.51	116.0	146.5	.00785
W-20[1]......	143	.....do...........	.....do.............	60	24.65	225	3,085	572	655	6.875	83.3	591	26.97	5½	27.05	2,325	86.4	14.49	......	150.0	.00751
W-20[1]......	144	.....do...........	.....do.............	60	24.65	225	3,085	555	634	6.585	84.4	564	26.97	5½	27.05	2,335	86.6	14.83	......	157.8	.00729
W-20[1]......	145	.....do...........	.....do.............	60	24.65	225	3,085	586	665	7.405	79.1	625	26.97	5⅜	27.05	2,370	88.0	14.81	......	162.8	.00770
W-20[1]......	146	.....do...........	.....do.............	50	20.5	100	1,371	247.5	283	2.570	96.2	217.5	27.19	5⅝	26.12	2,360	86.9	15.89	208.0	154.0	.00880
W-20[1]......	[2] 147	.....do...........	.....do.............	50	20.5	150	2,056	254	295	2.880	88.2	245	27.19	5	26.12	2,350	86.5	13.73	113.0	154.9	.00603
W-20[1]......	[3] 148	.....do...........	Same as for No. 147.	50	20.5	250	3,427	222	254	2.590	85.7	218.3	27.19	6	26.12	2,370	87.1	12.38	......	147.1	.00316
W-20[1]......	149	.....do...........	Same, not redressed.	50	20.5	100	1,371	266	294	2.617	101.7	224	27.19	4⅜	26.12	2,340	86.1	18.53	......	162.0	.00945
W-20[1]......	[2] 150	.....do...........	.....do.............	50	20.5	150	2,056	263	284	2.685	97.9	227.8	27.19	6⅜	26.12	2,360	86.9	9.69	133.0	161.0	.00624
W-20[1]......	[3] 151	.....do...........	.....do.............	50	20.5	250	3,427	226	265	2.405	94.0	206	27.19	5	26.12	2,335	85.9	11.63	......	155.0	.00322
W-9[1]......	152	.....do...........	.....do.............	30	12.3	225	3,085	324	362	1.890	171.3	190.6	24.13	9⅝	32.00	1,983	82.3	11.30	......	181.9	.00853
W-20[1]......	153	.....do...........	.....do.............	30	12.3	225	3,085	298	340	1.233	241.8	116.3	26.91	5	22.93	2,120	78.9	17.57	......	186.0	.00785
W-20[1]......	[2] 154	.....do...........	.....do.............	100	41.0	225	3,085	652	706	6.490	100.6	637	26.91	5	22.93	2,035	75.6	25.78	......	152.0	.00515
W-20[1]......	155	Straight cut, 3 to inch; spiral cut, 10 to inch.	([4])	40	16.4	225	3,085	444	489	2.205	200.6	194.6	28.20	5	22.10	2,270	80.5	5.05	......	86.5	.00876
W-20[1]......	156	.....do...........	Same, not redressed.	40	16.4	225	3,085	382	446	1.825	209.4	163	28.20	4⅞	22.10	2,240	79.5	12.31	......	187.2	.00754
W-20[1]......	[2] 157	.....do...........	.....do.............	80	32.8	225	3,085	511	571	3.850	133	339	28.20	5	22.10	2,270	80.5	9.39	......	86.0	.00505
W-20[1]......	[2] 158	.....do...........	.....do.............	80	32.8	225	3,085	474	509	4.160	113.9	363	28.20	5¼	22.10	2,290	81.2	20.70	......	169.0	.00468

[1] Seasoned.
[2] Wood was ground in two pockets at a time.
[3] Wood was ground in one pocket at a time.
[4] Approximately 1 ton of pulp was made on this surface before conducting test.

TABLE 4.—*Grinder runs on green and seasoned spruce, steamed prior to grinding.*

Wood shipment number.	Run number.	Steaming treatment. Duration of cook.	Steaming treatment. Gauge pressure.	Surface of stone.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed.	Average horsepower to grinder.	Maximum horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bonedry pulp in 24 hours.	Solid wood ground in 24 hours.	Bone-dry weight per cubic foot, wood.	Dimensions of wood. Diameter.	Dimensions of wood. Length.	Per cent moisture in wood.	Bone-dry pulp per 100 cubic feet solid rossed wood.	Efficiency of conversion.	Weight of screenings per 100 cubic feet solid rossed wood.	Stock in white-water per 100 cubic feet solid rossed wood.	Average temperature of grinding.	Constant $\frac{HP.}{P \times S}$
		Hrs.	*Lbs.*		*Lbs.*	*Lbs.*		*Ft. per min.*			*Tons.*		*Cu. ft.*	*Lbs.*	*In.*	*Ft.*		*Lbs.*	*P. ct.*	*Lbs.*	*Lbs.*	*° F.*	
W-9[1]	51	8	60	[2]	40	16.4	200	2,762	326	372	3.130	104	340	22.96	9 7/8	1	39.08	1,840	80.2	18.47		156.6	0.00719
W-17[1]	57	[3] 4	60	Same as for No. 56 [4]	40	16.4	200	2,762	335	394	3.380	99.2	296	27.11	5 1/4	2	25.31	2,283	84.4	23.60		156	.00739
W-18[1]	72	8	60	[2]	40	16.4	200	2,762	301	358	2.250	133.9	250	25.06	6 1/8	2	30.36	1,800	71.9	16.15		166.4	.00664
W-18[1]	73	2	60	[2]	40	16.4	200	2,762	352.5	415	2.800	126	264	26.84	5 5/8	2	30.73	2,122	79.0	19.25		164.1	.00777
W-18[1]	77	4	60	Same, not redressed	20	8.2	175	2,417	172.2	212	.784	220	79.2	26.06	5 1/4	2	31.29	1,980	76.0	12.48		171	.00871
W-18[1]	78	4	60	do	40	16.4	175	2,417	299	349	2.155	138.8	208.5	27.48	6	2	28.61	2,066	75.2	18.19		158.2	.00755
W-18[1]	79	4	60	do	60	24.65	175	2,417	373	449	2.935	127.1	292	27.14	6 1/8	2	28.83	2,013	74.2	23.90		149.4	.00626
W-18[5]	[6] 97	6	60	Freshly dressed	20	8.2	225	3,092	153.2	189	1.803	84.9	197.8	26.66	6 5/8	2	36.51	1,823	68.4	10.08		131.5	.00605
W-18[5]	[6] 98	6	60	Same, not redressed	40	16.4	225	3,092	229.5	272	3.365	63.1	352	27.19	6	2	39.66	1,910	70.3	18.32		121.1	.00452
W-18[5]	[6] 99	6	60	do	60	24.65	225	3,092	308.2	360	4.020	76.7	426	27.19	7	2	39.66	1,883	69.4	27.37		120.2	.00404
W-18[5]	[6] 100	6	60	do	80	32.8	225	3,092	363	401	4.655	79.1	496	27.19	6 1/4	2	39.66	1,876	69.0	34.00	73.1	125.1	.00364
W-18[5]	[6] 101	6	60	do	100	41.0	225	3,092	420	510	4.615	90.9	487	27.19	6 1/8	2	39.66	1,896	69.7	45.85	159	128.4	.00332
W-18[5]	[7] 102	6	60	Freshly dressed	40	16.4	200	2,748	280	320	3.075	91.1	376	25.06	6 1/4	2	44.00	1,636	65.3	18.57	119	125	.00621
W-18[1]	103	2	20	Same, not redressed	40	16.4	200	2,748	332	382	4.195	79.1	378	27.81	6 1/2	2	26.22	2,219	79.7	12.28	111	128.7	.00736
W-18[1]	104	4	20	do	40	16.4	200	2,748	323	393	4.210	76.7	390	27.81	6 3/8	2	26.22	2,160	77.6	16.86	103	137	.00716
W-18[1]	105	6	20	do	40	16.4	200	2,748	326.5	364	3.995	81.8	422	27.81	5 3/4	2	26.22	1,892	68.0	10.36	89.0	126.1	.00725
W-18[1]	106	8	20	do	40	16.4	200	2,748	320	382	3.595	89.1	346	27.30	5 5/8	2	27.56	2,081	76.3	17.81		137.8	.00710
W-18[1]	107	12	20	do	40	16.4	200	2,748	323	398	3.565	90.6	344	27.30	5 7/8	2	27.56	2,070	75.8	19.93	42.7	136.4	.00716
W-18[1]	108	2	40	do	40	16.4	200	2,748	339	393	3.810	89	337	26.50	5 1/2	2	29.88	2,263	85.5	16.53		144.9	.00752
W-18[1]	109	4	40	do	40	16.4	200	2,748	307	363	3.705	82.9	342	26.50	5 5/8	2	29.88	2,170	82.0	21.80	124	134.0	.00681
W-18[1]	110	6	40	do	40	16.4	200	2,748	285	342	2.927	97.4	278	26.50	5 1/4	2	29.88	2,105	79.5	15.80	61.5	142.2	.00632
W-18[1]	111	8	40	do	40	16.4	200	2,748	275	323	3.037	90.6	304	26.50	5 3/8	2	29.88	2,000	75.5	12.98		139.5	.00610
W-18[1]	113	12	40	Same as for 112 [4]	40	16.4	200	2,748	288	342	2.985	96.5	299	26.50	5 1/2	2	29.88	1,998	75.4	10.40		143.7	.00639
W-18[7]	115	2	60	Same as for 114 [4]	40	16.4	200	2,748	294	368	3.260	90.1	314	27.19	5 7/8	2	39.66	2,080	76.5	10.96		137.9	.00652
W-18[5]	116	4	60	Same, not redressed	40	16.4	200	2,748	252	303	2.475	101.9	270	25.05	6 1/4	2	40.34	1,830	73.2	19.30		140.8	.00559
W-18[6]	117	6	60	do	40	16.4	200	2,748	271	328	2.540	106.7	294.5	25.05	6	2	40.34	1,722	68.8	11.13		138.1	.00601
W-18[5]	118	8	60	do	40	16.4	200	2,748	283	329	2.775	102	325	25.05	6	2	40.34	1,710	68.3	14.76	105	138.6	.00627
W-18[7]	119	12	60	do	40	16.4	200	2,748	277	329	2.805	98.8	336	25.05	6 3/8	2	40.34	1,670	66.7	13.10	113	138.6	.00614
W-20[1]	130	4	60	Same as for No. 129 [4]	60	24.65	225	3,085	495	590	5.110	96.7	482	28.01	5 1/8	2	29.09	2,124	75.9	45.70	281	143.6	.00650
W-20[1]	131	4	60	Same, not redressed	40	16.4	225	3,085	378	435	3.807	99.3	362	27.66	4 5/8	2	28.08	2,100	75.9	19.87	321	145.1	.00746
W-20[1]	132	4	60	do	20	8.2	225	3,085	230	268	1.977	116.3	186.8	27.66	4 1/2	2	28.08	2,118	76.5	10.55		149.3	.00908

[1] Seasoned.
[2] Approximately 1 ton of pulp was made on the stone before this test was run.
[3] Boiled in 0.3 per cent soda ash solution.
[4] See Table 3.
[5] Green.
[6] Wood was ground in but two pockets at a time.
[7] Not barked.

NOTE.—Kind of burr: Straight cut, 3 to the inch; and spiral cut, 12 to the inch. Kind of stone: Lombard.

TABLE 5.—*Quality tests of papers manufactured from experimental pulps.*

Grinder run number.	Paper-machine run number.	Weight per ream.	Thickness.	Mullen test. Total.	Mullen test. Per 0.001 inch of thickness.	Mullen test. Per pound.	Mullen test. Horsepower per ton divided by strength factor.	Schopper tests. Breaking length. Cross-wise.	Schopper tests. Breaking length. Length-wise.	Schopper tests. Breaking length. Average.	Schopper tests. Stretch. Cross-wise.	Schopper tests. Stretch. Length-wise.	Schopper tests. Stretch. Average.	Schopper tests. Breaking weight per square millimeter, sectional area.	Schopper tests. Breaking length per horsepower per ton.	Tintometer indications. Red.	Tintometer indications. Green.	Tintometer indications. Blue.	Tintometer indications. Black.	Microscopic classification.
		Pounds.	*Inches.*	*Points.*	*Points.*	*Points.*		*Meters.*	*Meters.*	*Meters.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Meters.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	
1																				1
2	110	32	0.00387	12.15	3.14	0.380	256	2,000	4,000	3,300	3.00	1.40	2.20	1,506	33.9	95	86	78	41	1
3	62	32	.0036	16.4	4.55	.513	306	3,075	5,300	4,188	2.04	1.22	1.63	2,050	26.7	89	80	73	58	1
4	75	37	.0041	19.35	4.72	.523	210	3,585	6,040	4,821	1.98	1.04	1.51	2,440	43.8	87	76	66	71	2
5	42	29	.0038	11.3	2.97	.390	221	2,420	4,640	3,530	1.74	.98	1.36	1,462	40.8	89	78	68	65	2
6	11	40	.0047	21.4	4.55	.535	351	2,500	5,440	3,970	1.18	1.10	1.14	1,936	21.2	90	80	70	60	1
7	22	33	.0038	15.7	4.13	.476	229	3,120	6,210	4,665	1.76	1.06	1.41	2,130	42.8	88	79	69	64	2
8	56	34	.0043	14.05	3.27	.413	221	2,673	4,780	3,727	1.66	1.10	1.38	1,590	40.9	87	77	64	72	5
9	51	33	.00384	17.95	4.72	.544	323	3,344	5,690	4,517	2.86	1.58	2.22	2,350	25.7	82	71	61	86	2
9–1	16	35	.0046	17.50	3.74	.493	189	3,040	5,410	4,225	1.58	.98	1.28	1,272	45.2	96	79	75	50	1
10	72	33	.00394	14.15	3.60	.429	174	2,973	5,358	4,166	1.40	1.04	1.22	1,975	55.9	81	73	66	80	4
11	45	34	.0042	12.35	2.94	.363	180	2,123	4,335	3,229	2.92	1.30	2.11	1,360	49.3	91	78	70	61	4
12	92	34	.00417	15.65	3.75	.460	163	3,180	5,320	4,250	1.78	1.22	1.50	1,895	56.6	97	85	76	42	2
13	20	34	.0040	13.00	3.25	.382	176	2,655	5,030	3,843	1.98	1.10	1.54	1,680	57.3	90	79	66	65	2
14	28	34	.0047	13.00	2.77	.382	170	2,065	4,325	3,195	1.94	1.12	1.53	1,330	49.2	90	79	69	62	4
14	29	32	.00414	11.45	2.77	.358	181	2,228	4,020	3,124	1.74	1.02	1.38	1,240	48.2	90	80	74	56	4
15	61	30	.00343	16.55	4.83	.552	231	3,865	5,750	4,808	2.22	1.10	1.66	2,340	37.7	84	72	66	78	4
16	19	38	.0043	17.45	4.06	.459	192	3,098	5,960	4,529	2.16	1.26	1.71	2,114	51.3	85	75	64	76	5
17	48	33	.00298	13.40	4.47	.406	196	2,395	3,795	3,095	2.40	.98	1.64	1,940	38.8	88	73	65	74	2
18	73	29	.0033	14.50	4.40	.500	224	3,085	5,850	4,468	1.76	1.16	1.46	2,119	39.9	86	77	70	67	2
19	91	35	.00397	16.35	4.12	.467	192	3,350	5,360	4,355	2.00	1.20	1.60	2,085	48.5	95	82	75	48	4
20	43	31	.0039	13.90	3.56	.448	183	2,865	4,855	3,860	1.94	1.00	1.47	1,613	47.1	92	82	71	55	4
21	21	44	.0045	25.6	5.69	.582	249	3,384	6,680	5,032	2.56	1.48	2.02	2,700	34.8	87	78	67	68	4
22	77	33	.00354	17.15	4.85	.520	273	3,400	5,850	4,625	2.02	1.24	1.63	2,350	32.6	82	69	61	88	2
23	79	33	.00355	18.7	5.27	.567	236	3,570	5,910	4,740	2.46	1.24	1.85	2,420	35.3	84	75	70	71	2
24	67	33	.0037	16.75	4.53	.508	196	3,165	5,430	4,298	2.22	1.32	1.77	2,010	43.1	86	74	67	73	5
25	59	31	.00373	15.9	4.30	.513	174	3,045	4,840	3,943	2.18	1.18	1.68	1,850	44.1	78	66	58	98	5

26	50	36	.0041	17.9	4.36	.497	178	3,000	5,650	4,325	2.60	1.60	2.10	2,150	48.7	88	75	64	73	5
27	8	33	.0042	13.85	3.30	.420	194	2,445	5,018	3,732	1.24	1.05	1.15	1,656	45.8	85	71	66	78	5
28	95	35	.0039	18.2	4.67	.520	229	2,965	5,200	3,833	2.00	1.08	1.54	2,185	32.1	95	79	71	55	5
29	96	32	.00365	16.1	4.41	.503	240	3,570	5,480	4,525	2.04	1.12	1.58	2,170	37.6	88	79	71	62	5
29–1	64	31	.0036	15.15	4.21	.489	261	3,195	5,020	4,108	2.22	1.14	1.68	1,975	32.2	85	76	68	71	2
30	58	31	.00364	15.00	4.17	.484	191	3,295	5,400	4,348	2.12	1.14	1.63	1,914	47.0	87	78	67	68	2
31	26	31	.0035	13.25	3.79	.427	234	3,050	5,480	4,255	1.72	1.08	1.40	1,928	42.5	91	80	72	57	2
32	66	31	.0041	8.5	2.07	.274	220	2,085	3,745	2,915	1.12	.94	1.03	1,220	48.2	87	78	71	64	3
33	24	33	.0045	10.0	2.22	.303	188	2,180	4,230	3,205	1.36	.88	1.12	1,254	56.2	87	77	69	67	3
34	17	33	.0047	10.75	2.29	.326	186	2,140	4,000	3,070	1.20	.88	1.04	1,260	50.6	90	76	66	68	3
35	23	33	.0044	11.7	2.66	.354	183.5	2,282	4,600	3,441	1.48	.96	1.22	1,365	53.1	83	72	61	84	4
36	18	32	.0041	11.45	2.73	.358	181	2,294	4,935	3,615	1.48	1.00	1.24	1,500	55.8	90	79	70	61	4
37	53	34	.0043	12.35	2.87	.363	174	2,700	4,060	3,380	2.04	1.12	1.58	1,414	53.5	86	74	66	74	4
37	55	34	.00436	12.35	2.83	.363	174	2,560	3,970	3,265	1.96	1.08	1.52	1,340	51.7	88	76	64	72	4
38	54	34	.0044	11.60	2.64	.341	197	2,330	3,570	2,950	1.78	1.08	1.43	1,236	44.0	83	70	61	86	4
39	69	30	.00363	9.95	2.74	.331	221	2,500	4,725	3,613	1.04	.98	1.01	1,570	49.5	81	70	62	87	5
40	14	33	.0044	13.80	3.14	.330	232	2,750	4,635	3,693	1.44	.98	1.21	1,615	48.2	89	74	65	72	4
41	74	30	.0039	12.10	3.10	.403	181	2,805	4,950	3,878	1.46	1.08	1.27	1,610	53.1	84	71	63	82	2
42	39	31	.0035	13.70	3.91	.442	229	2,773	5,280	4,026	2.14	1.12	1.63	2,014	39.8	87	76	72	65	5
43	47	32	.0037	13.8	3.73	.431	235	2,810	5,210	4,010	2.14	1.32	1.73	1,910	39.6	88	80	70	62	....
44	25	31	.0036	11.9	3.30	.384	224	2,650	5,170	3,910	1.40	1.00	1.20	1,695	45.5	84	72	61	83	....
45	52	35	.0037	15.95	4.31	.455	353	3,055	4,950	4,003	2.72	1.36	2.04	2,010	25.0	79	69	59	93	....
46	40	30	.0038	14.45	3.80	.482	197	5,280	5,135	3,858	2.54	1.22	1.88	1,710	40.7	87	79	70	64	....
47	44	32	.0040	13.6	3.40	.425	188	2,714	4,620	3,517	2.54	1.54	2.04	1,545	44.0	87	75	66	72	....
48	60	32	.0036	14.6	4.05	.456	288	3,455	5,415	4,435	2.02	1.00	1.51	2,200	33.8	80	70	61	89	....
49	49	32	.00356	14.8	4.11	.462	246	3,014	5,280	4,147	2.14	1.28	1.71	1,940	36.5	84	73	68	75	....
50	41	33	.0040	14.7	3.68	.444	210	2,890	5,300	4,095	1.72	1.06	1.39	1,840	44.0	86	79	69	66	....
51	85	36	.0037	20.5	5.55	.569	183	3,460	5,400	4,430	2.68	1.16	1.92	2,355	42.6	58	40	36	166	1
52	97	35	.00295	17.35	5.88	.495	366	3,525	4,805	4,165	1.92	.84	1.38	2,880	23.0	83	76	68	73	2
53	63	29	.00336	11.25	3.35	.388	270	2,925	5,155	4,040	1.84	1.14	1.49	1,810	38.6	89	79	69	63	2
54	62	35	.00423	13.30	3.14	.380	180	2,985	4,580	3,783	1.84	1.16	1.50	1,728	55.5	83	73	69	75	4
55	68	29	.0039	8.9	2.28	.306	195	2,445	4,260	3,353	1.50	1.02	1.26	1,395	56.2	88	78	71	63	4
56	71	31	.0048	10.5	2.48	.326	175	2,300	4,060	3,180	1.18	.92	1.05	1,394	55.8	86	74	66	74	4
57	80	35	.0041	16.45	4.01	.470	211	3,245	5,350	4,298	2.26	1.18	1.72	1,934	43.3	82	68	63	87	1
58	83	32	.00417	11.45	2.74	.358	173	2,715	4,385	3,550	1.44	1.00	1.22	1,517	57.2	87	75	68	70	3
59	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
60	86	30	.0036	13.85	3.85	.461	199.5	3,110	5,190	4,150	1.82	1.20	1.51	2,000	45.1	91	81	72	56	5
61	87	33	.00375	15.95	4.25	.483	189	3,110	5,000	4,055	2.20	1.36	1.78	1,953	44.3	91	79	74	56	4
62	81	34	.00416	14.05	3.38	.413	210	3,040	4,865	3,953	2.04	1.18	1.61	1,775	45.5	91	78	69	62	4
63	78	32	.0040	12.15	3.04	.380	215	2,910	5,040	3,975	1.52	1.10	1.31	1,712	48.6	85	76	67	72	4
64	76	29	.00365	11.95	3.28	.412	191	2,760	4,635	3,697	1.60	1.02	1.31	1,640	47.0	88	76	67	69	5
65	6	33	.0040	11.40	2.85	.345	233	2,445	4,829	3,637	1.63	1.01	1.32	1,569	45.1	87	75	66	72	4
66	57	33	.00425	14.05	3.31	.426	194.5	2,910	4,635	3,773	2.00	1.10	1.55	1,640	45.5	84	72	62	82	4

TABLE 5.—*Quality tests of papers manufactured from experimental pulps*—Continued.

Grinder run number.	Paper-machine run number.	Weight per ream.	Thickness.	Mullen test. Total.	Mullen test. Per 0.001 inch of thickness.	Mullen test. Per pound.	Mullen test. Horsepower per ton divided by strength factor.	Schopper tests. Breaking length. Crosswise.	Schopper tests. Breaking length. Lengthwise.	Schopper tests. Breaking length. Average.	Schopper tests. Stretch. Crosswise.	Schopper tests. Stretch. Lengthwise.	Schopper tests. Stretch. Average.	Schopper tests. Breaking weight per square millimeter, sectional area.	Schopper tests. Breaking length per horsepower per ton.	Tintometer indications. Red.	Tintometer indications. Green.	Tintometer indications. Blue.	Tintometer indications. Black.	Microscopic classification.
		Pounds.	*Inches.*	*Points.*	*Points.*	*Points.*		*Meters.*	*Meters.*	*Meters.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Meters.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	
67	4	35	0.0052	12.35	2.38	0.353	211	2,155	4,218	3,187	1.35	1.02	1.19	1,395	42.8	86	76	66	73	3
68	13	34	.0047	14.75	3.14	.434	188.5	2,750	4,840	3,795	1.72	1.06	1.39	1,610	46.4	89	79	70	62	4
69	12	32	.0043	12.8	2.98	.400	171.5	2,485	4,450	3,467	1.58	.96	1.27	1,510	48.3	92	83	73	52	4
70	3	32	.0042	9.2	2.18	.288	219	2,053	4,095	3,074	1.26	.95	1.11	1,203	48.8	84	70	62	84	4
71	10	34	.0046	11.15	2.42	.328	185.5	2,045	4,150	3,088	1.64	.98	1.31	1,310	50.8	84	76	74	66	4
72	166	37	.00354	18.30	5.169	.4946	271	3,050	5,206	4,128	2.08	1.18	1.63	2,368	30.8	46	31	24	199	....
73	170	33	.00458	19.00	4.150	.576	218	3,000	4,780	3,890	2.42	1.26	1.84	1,940	30.9	57	45	39	159	....
74	175	32	.00369	10.15	2.750	.3170	283	1,985	3,705	2,845	2.00	1.10	1.55	1,421	31.7	68	61	54	117	....
75	176	34	.00374	15.00	4.01	.4415	258	2,898	4,852	3,875	2.30	1.30	1.80	1,982	34.1	68	66	56	115	....
76	177	34	.00357	17.25	4.83	.5075	371	2,965	5,635	4,300	2.14	1.36	1.75	2,235	22.8	67	58	55	120	....
77	171	35	.00348	17.50	5.030	.500	440	3,100	5,430	4,265	2.56	1.54	2.05	3,240	19.4	45	32	27	196	....
78	167	36	.00372	19.90	5.350	.5532	251	3,408	5,424	4,416	2.34	1.20	1.77	2,425	31.8	63	44	38	155	....
79	192	33	.00349	17.70	5.070	.5364	237	3,520	6,744	5,132	1.84	1.08	1.46	2,801	40.3	53	34	27	186	....
80	190	31	.00326	15.85	4.86	.5112	559	3,688	7,460	5,574	1.80	1.18	1.49	3,002	19.5	76	70	64	90	....
81	191	31	.00351	13.90	3.96	.4484	295	3,459	6,631	5,045	1.94	1.06	1.50	2,439	38.1	97	85	70	48	....
82	172	35	.00408	14.00	3.43	.405	242	2,475	4,100	3,288	2.34	1.32	1.83	1,580	33.6	67	55	48	130	....
83	184	31	.00367	11.70	3.19	.3775	261	2,995	5,100	4,047	1.72	1.04	1.38	1,891	41.0	75	67	61	97	....
84	183	34	.00414	15.54	3.73	.4545	258	2,840	5,270	4,055	1.74	1.10	1.42	1,893	34.6	78	65	62	95	....
85	169	35	.00899	14.20	3.312	.4060	228	3,176	4,826	4,001	1.90	1.04	1.47	1,958	43.1	87	76	69	68	....
86	178	34	.40042	14.10	3.37	.4100	216	2,890	4,850	3,870	1.72	.98	1.35	1,725	43.7	75	65	60	100	....
87	179	34	.00399	15.50	3.89	.4565	265	3,095	5,685	4,390	1.78	1.16	1.43	2,140	36.2	86	78	71	65	....
88	163	30	.00367	11.80	3.217	.3935	290	2,830	4,688	3,759	2.06	1.22	1.64	1,748	32.9	84	74	71	71	....
	180	35	.00400	14.25	3.56	.4070	281	2,883	4,610	3,746	1.82	1.18	1.50	1,803	32.8	92	81	73	54	....
89	181	32	.00394	10.65	2.70	.3200	268	2,578	4,460	3,519	1.44	.92	1.18	1,637	41.0	85	72	68	75	....
90	182	32	.00417	11.25	2.70	.3517	224	2,700	4,228	3,464	1.54	.82	1.18	1,508	44.1	87	78	69	66	....
91	198	30	.00361	12.35	3.42	.4117	283	2,862	5,722	4,292	1.58	1.04	1.31	1,743	36.9	80	71	68	81	....
(1)	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....

97	145	34	.00363	19.20	5.292	.5650	150	2,890	6,012	4,451	2.42	1.06	1.74	2,293	52.5	61	41	32	166	....
98	146	34	.00349	17.30	4.957	.5088	134	2,832	5,694	4,263	2.56	1.34	1.95	2,238	62.6	54	35	29	182	....
99	193	30	.00318	13.15	4.135	.4385	175	2,881	6,287	4,584	1.88	1.02	1.45	2,421	59.7	65	43	35	157	....
100	165	33	.00347	16.25	4.684	.4926	161	2,715	5,345	4,030	2.50	1.32	1.91	2,117	51.0	54	37	30	179	....
101	196	31	.00337	15.20	4.51	.4905	185	2,630	5,538	4,084	1.98	1.14	1.56	2,072	45.0	55	38	31	176	....
102	186	33	.00338	16.15	4.780	.4895	186	3,114	5,732	4,423	1.80	.96	1.38	2,350	48.5	43	30	22	205	....
103	158	33	.00417	12.40	2.974	.3757	211	2,863	5,107	3,985	1.94	1.20	1.57	1,801	50.3	78	64	57	101	....
104	159	34	.00350	16.50	4.715	.4851	158	3,392	5,760	4,576	2.20	1.28	1.74	2,137	59.7	76	64	57	103	....
105	187	32	.00386	16.50	4.280	.5160	158	3,575	5,945	4,760	1.76	.92	1.34	2,339	58.3	74	59	50	117	....
106	195	30	.00353	14.85	4.21	.495	180	2,901	5,891	4,396	2.16	1.00	1.59	2,060	49.4	72	58	49	121	....
107	194	33.2	.00375	17.55	4.68	.529	171	3,395	6,328	4,860	2.20	.98	1.59	2,455	53.6	68	53	44	135	....
108	135	31	.00386	13.95	3.616	.4536	196	3,048	5,460	4,254	2.32	1.18	1.75	1,942	47.8	78	62	53	107	....
109	136	33	.00375	17.35	4.630	.5258	157.5	3,155	5,900	4,528	2.48	1.24	1.86	2,203	54.6	65	48	41	146	....
110	139	34	.003735	21.30	5.703	.6266	155	3,200	6,176	4,688	2.30	1.32	1.81	2,473	48.1	59	42	36	163	....
111	138	34	.003645	20.45	5.612	.6015	150.8	3,343	6,620	4,970	2.38	1.26	1.82	2,590	54.9	54	38	30	178	....
	144	32	.0032	18.50	5.78	.5781	157	3,270	6,100	4,685	2.18	1.22	1.70	2,490	51.6	57	40	30	173	....
112	142	20	.00393	11.50	2.928	.3834	197	2,731	4,711	3,721	1.62	.98	1.30	1,580	49.3	88	74	67	71	....
113	148	32	.00328	18.15	5.536	.5674	170	2,860	4,870	3,865	2.42	1.36	1.89	2,130	40.0	54	34	27	185	....
114	149	31	.00398	10.25	2.578	.3307	223	2,362	4,066	3,214	1.74	1.08	1.41	1,430	43.5	85	76	65	74	....
115	151	33	.00398	14.00	3.518	.4241	213	3,074	5,510	4,292	2.12	1.04	1.58	1,950	47.5	71	53	47	129	....
116	150	31	.00341	17.15	5.030	.5500	185	2,774	5,874	4,324	2.54	1.12	1.83	2,236	42.5	63	48	41	148	....
117	185	31	.00337	16.95	5.030	.5470	195	2,902	5,995	4,448	1.86	1.00	1.43	2,379	41.7	51	33	25	191	....
118	155	32	.00337	14.30	4.245	.4470	228	2,826	5,010	3,918	2.84	1.04	1.94	2,158	38.4	51	32	27	190	....
119	156	32	.00323	14.15	4.380	.4430	223	2,768	4,748	3,758	3.12	1.02	2.07	2,122	38.0	42	26	20	212	....
120	153	31	.00422	8.35	1.979	.2694	216	2,572	3,910	3,241	1.74	.92	1.33	1,315	55.6	80	70	61	89	....
121	152	33	.00429	12.20	2.843	.3698	178	2,870	4,722	3,796	1.44	1.00	1.22	1,731	57.7	85	74	67	74	....
122	173	34	.00408	14.25	3.50	.419	212	2,580	4,565	3,568	2.44	1.20	1.82	1,590	40.1	65	56	52	127	....
123	157	34	.00416	12.65	3.040	.3720	234	3,064	4,442	3,753	1.88	1.06	1.47	1,748	43.1	89	78	74	59	....
124	134	32	.00386	12.45	3.225	.3890	204	2,716	4,765	4,740.5	1.74	1.20	1.47	1,701	47.0	88	82	72	58	....
125	141	31	.00365	14.35	3.932	.4630	207	3,288	5,460	4,374	2.22	1.36	1.79	2,080	45.8	93	82	76	49	....
126	131	32	.003515	15.35	4.369	.4796	284	3,172	5,185	4,178.5	2.96	1.38	2.17	2,078	30.7	91	81	73	55	....
127	133	33	.0043	13.775	3.204	.4175	196	2,574	4,212	3,393	2.68	1.38	2.03	1,672	41.	89	75	69	67	....
128	188	32.4	.00373	15.10	4.05	.4660	199	3,257	5,585	4,421	1.84	.96	1.40	2,101	47.5	88	72	68	72	....
129	154	31	.00334	16.40	4.910	.5290	288	3,810	6,348	5,079	2.58	1.22	1.90	2,448	33.3	79	69	57	95	....
130	137	34	.00352	19.40	5.514	.5709	169.5	3,152	6,072	4,612	2.38	1.14	1.76	2,334	47.6	61	39	31	169	....
131	124	30	.0031	19.90	6.41	.663	150	2,684	5,350	4,017	1.90	1.36	1.63	2,195	40.5	77	57	49	117	....
132	125	33	.00332	22.3	6.72	.675	173	2,876	5,552	4,214	2.36	1.42	1.89	2,224	36.2	63	46	39	152	....
133	126	34	.00405	15.1	3.73	.444	196	2,958	4,662	3,810	2.26	1.38	1.82	1,815	43.8	94	83	74	49	....
134	189	31	.00379	11.90	3.14	.3839	255	3,152	5,712	4,432	1.68	1.06	1.37	2,068	45.3	83	72	66	79	....
135	140	30	.003755	10.55	2.810	.3518	199	2,700	4,591	3,645.5	1.58	1.00	1.29	1,596	52.3	89	79	69	63	....
136	129	34	.004555	13.35	2.93	.3928	183	2,466	3,958	3,212	2.92	1.18	2.05	1,437	44.5	87	74	68	71	....

[1] 92–96, inclusive, qualitative grinder runs (no production data). No pulp made for paper machine runs.

TABLE 5.—*Quality tests of papers manufactured from experimental pulps*—Continued.

Grinder run number.	Paper-machine run number.	Weight per ream.	Thickness.	Mullen test.				Schopper tests.								Tintometer indications.				Microscopic classification.
				Total.	Per 0.001 inch of thickness.	Per pound.	Horsepower per ton divided by strength factor.	Breaking length. Crosswise.	Breaking length. Lengthwise.	Breaking length. Average.	Stretch. Crosswise.	Stretch. Lengthwise.	Stretch. Average.	Breaking weight per square millimeter, sectional area.	Breaking length per horsepower per ton.	Red.	Green.	Blue.	Black.	
		Pounds.	*Inches.*	*Points.*	*Points.*	*Points.*		*Meters.*	*Meters.*	*Meters.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Meters.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	
137	127	32	0.00378	16.85	4.46	0.5267	244	3,600	6,004	4,802	1.96	1.12	1.54	2,526	37.4	84	74	65	77	....
138	121	31	.00359	15.25	4.25	.492	200	3,255	4,920	4,088	2.98	1.34	2.16	1,952	41.5	86	73	67	74	....
139	123	33	.00409	16.95	4.15	.514	155	2,962	4,776	3,869	2.74	1.36	2.05	1,830	48.6	87	76	69	68	....
140	143	31	.00356	15.00	4.212	.4840	263	3,810	5,840	4,825	2.40	1.12	1.76	2,253	38.0	87	76	66	71	....
141	130	32	.004045	15.25	3.77	.4766	194	2,740	4,590	3,665	2.98	1.40	2.19	1,756	39.6	80	72	67	81	....
142	132	32	.0042	11.80	2.809	.3689	218	2,452	3,968	3,210	2.44	1.30	1.87	1,495	39.9	89	78	72	61	....
143	122	33	.00426	14.8	3.47	.448	186	2,805	4,380	3,593	2.34	1.32	1.83	1,608	43.1	86	76	68	70	....
144	118	31	.00414	14.05	3.54	.4725	178	2,712	4,350	3,531	2.44	1.40	1.92	1,660	41.9	87	76	72	65	....
145	128	33	.004185	13.175	3.149	.3993	198	2,831	4,981	3,906	1.90	1.10	1.50	1,605	49.4	88	79	70	63	....
146	168	31	.00375	12.10	3.228	.3902	246	3,086	4,716	3,901	1.60	1.04	1.32	1,805	40.5	83	70	64	83	....
147	160	35	.00407	14.65	3.599	.4187	210	3,266	4,680	3,973	2.84	1.22	2.03	1,917	45.0	85	76	68	71	....
148	164	32	.00405	12.50	3.087	.3906	220	2,728	4,860	3,794	2.14	1.26	1.70	1,846	44.2	83	72	65	80	....
149	174	33	.00350	11.00	3.140	.3375	302	2,658	4,628	3,643	2.58	1.36	1.97	1,730	35.8	66	56	50	128	....
150	161	32	.00398	12.35	3.104	.3859	254	3,064	4,554	3,809	2.20	1.10	1.65	1,848	38.9	80	69	64	87	....
151	162	34	.00418	14.70	3.518	.4326	217	3,162	4,818	3,990	2.40	1.16	1.78	1,944	42.5	84	72	68	76	....
152	197	30.4	.00355	15.10	4.25	.4965	345	3,401	6,259	4,830	1.66	1.04	1.35	2,305	28.2	89	77	73	61	....